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FOSSIL PLANTS
OF THE
CARBONIFEROUS ROCKS OF GREAT BRITAIN.

BY
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NOTE ON THE SPORANGIA AND MICROSPORANGIA OF FERNS AND PTERIDOSPERMS.

Before describing the genera of Ferns and Pteridosperms founded on characters derived from their sporangia or microsporangia, it is desirable to make a few general remarks on the subject of these fructifications.

Until the recognition of the important group of the seed-bearing Pteridosperms, all fern-like plants were believed to belong to the Filicaceæ; those on which annulate sporangia occurred were referred to the Leptosporangiate ferns, while those that bore exannulate sporangia were classed with the Marattiaceæ.

Since the recognition of the Pteridosperms, it has become necessary to reconsider, with due reference to the sporangia, the whole question of the systematic position of all those fossil remains which had been supposed to be Ferns, and to discuss the value of the sporangia as a means of separating Ferns from Pteridosperms.

Very many of these fern-like plants which bear exannulate sporangia are now known to belong to the Pteridosperms, or seed-bearing plants, which have fronds similar to those of Ferns. The opinion, held for some time, that the Pteridosperms were derived from Ferns, is now no longer tenable, for in the most remote period in geological times to which Ferns can be traced Pteridosperms also occur, with all their distinctive characters clearly defined. Although all the sporangia or microsporangia that have at present been definitely referred to the Pteridosperms are exannulate, yet all exannulate sporangia do not belong to them, for in *Asterotheca*, the sporangia are also exannulate; and if the Fern stems known as *Caulopteris* and *Psaronius* are those of *Asterotheca* (as there is good reason to believe) then *Asterotheca* may be Marattiaceous. Probably a few other Carboniferous plants that bear exannulate sporangia may be also referable to the Marattiaceæ, but all that may be with certainty referred to that class are of Upper Carboniferous age; at least none of the Lower Carboniferous species with exannulate sporangia suggest such a relationship. On the other hand, some Lower Carboniferous species with exannulate microsporangia are definitely known to be Pteridosperms, and of the others, the majority, I strongly suspect, belong to the same group. One is not, however, in a position to speak too positively on this subject, but all the available evidence points in this direction.

To return to the Upper Carboniferous exannulate sporangia, other than those of *Asterotheca* Presl and perhaps *Ptychocarpus* Weiss, which are possibly Marattiaceous, there are the undoubted Pteridospermous genera *Crossotheca* Zeiller and *Zeilleria* Kidston, but I believe that *Dactylotheca* Zeiller, *Renaultia* Zeiller, *Cyclotheca* Kidston, *Myriotheca* Zeiller and others are more probably Pteridospermous than Marattiaceous, though their true systematic position is still undetermined.

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In the two genera, *Urnatopteris* Kidston and *Sphyropteris* Stur, the free exannulate sporangia open by a small terminal pore, but notwithstanding this unusual mode of dehiscence and their similarity in this respect to the sporangia in the synangium of the existing genus *Danæa* Sm., I am not prepared to assign them to the Marattiaceæ. It should be noted that in nearly all these exannulate sporangia-bearing Upper Carboniferous genera, the sporangia are free and do not form synangia.

Those plants with fern-like fronds which bear annulate sporangia must now be considered. The genus *Corynepteris* Baily (=*Zygopteris*), the annulus of which is composed of many rows of cells, is universally classed with the Ferns, not only on account of its sporangia but perhaps more on anatomical grounds. In the great majority of cases where Carboniferous plants have borne annulate sporangia, these have most frequently been described as formed of a single row of cells, but in some cases, at least, the annulus is composed of two rows of cells and thus differs from any annulate sporangium found on existing Ferns.* One is certainly not justified in saying that a sporangium of Carboniferous age, with an annulus formed of one row of cells, did not exist; yet the existence of such an annulus at that date has not been satisfactorily demonstrated, and I think this point requires careful re-examination. Notwithstanding what has been said above, the structures of these annulate Carboniferous sporangia, though they may not be absolutely identical with those of existing Ferns, warrant the plants that bear them being provisionally classed with the Filicaceæ. The difficulty that arises in referring all these plants to the Filicaceæ is in regard to the Pteridosperms. It is true that at the present time, no Pteridosperm has been shown to possess an annulate sporangium, but one cannot say that none ever did. There are annulate and exannulate Ferns, and there might quite possibly also be annulate and exannulate Pteridosperms. Hence the value of the presence of an annulus on a sporangium in regard to the separation of Ferns from Pteridosperms has still to be determined.

These remarks are made to show the difficulty, and in many cases the impossibility, of referring the fertile Ferns or fern-like fronds to a definite systematic position, or in all cases of separating Ferns from Pteridosperms. Patient work will doubtless enable further progress to be made in this difficult task, but it will demand much careful observation.

Much speculation has been made as to the ancestry of Ferns and Pteridosperms, but has not advanced us in our knowledge of their line of descent, and up to the present palæontology has failed to reveal any clue as to their origin. They appear as two distinct groups as far back as they can be traced, and from the earliest time seem to have constituted two parallel and distinct lines of development.†

* The "annulus" of *Osmunda* is composed of a lateral group of cells, and scarcely vitiates the statement made above.

† In connection with this question, see Scott, *Rept. Brit. Assoc.* (Bournemouth), 1919, p. 334, 1920; also, by the same author, "The Origin of the Seed Plants" (Spermophyta): *Aberystwyth Studies*, vol. iv, p. 219, 1922 (Jubilee Volume of the University).

Genus Hymenophyllites Göppert.

1836. *Hymenophyllites* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, vol. xvii, p. 251.
1883. *Hymenophyllites* Zeiller, *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, p. 195.
1888. *Hymenophyllites* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 56.
1891. *Hymenophyllites* Solms-Laubach, "Fossil Botany" (English translation), p. 153.
1900. *Hymenophyllites* Zeiller, "Éléments de paléobot.," p. 67.
1910. *Hymenophyllites* Seward, "Fossil Plants," vol. ii, p. 363.

Description.—Fructification resembling that of *Hymenophyllum* and borne at the extremities of the lobes of the pinnules. Sporangia pyriform, pointed at the base and provided with a complete transverse annulus. Foliage of the small pinnuled *Sphenopteris* type.

Remarks.—Of Palæozoic plants, the species which has most claim to be included in the genus *Hymenophyllites* is the *Sphenopteris quadridactylites* Gutbier.* A fertile specimen of this species has been described by Zeiller † on which the structure of the sporangia was preserved. The sporangia are occasionally arranged in two slightly irregular rows, which extend outwards from the apex of the pinnule segments and have between the rows a narrow space. (Text-fig. 17.)

Text-fig. 17.—*Hymenophyllites quadridactylites* Gutbier sp. A, B, fertile segments of pinnules × 9; C–E, sporangia × 35. After Zeiller.

This space is supposed to have been originally occupied by a columella to which the sporangia were attached. Its presence has not, however, been demonstrated, though the late Prof. R. Zeiller informed me that he had observed what he believed to be traces of a columella in the middle of some of the groups of sporangia to which they were probably attached.

The minute structure of the annulus does not, however, seem to have been clearly made out, and whether it is formed of a single row of cells or of a greater number of rows was not determined, so far as I have been able to ascertain. It will therefore be seen that though the fructification of *Sphenopteris quadridactylites* Gutbier has some resemblance to that of *Hymenophyllum* Sm., there are several points on which additional information is necessary before it can be definitely referred to the *Hymenophyllaceæ*.

The genus *Hymenophyllites* has been employed for the reception of certain Carboniferous species for many years, but it is open to question if it is wise to use it for plants from that horizon, as none have as yet been clearly shown to belong to the *Hymenophyllaceæ*.

That described by Schimper, under the name of *Hymenophyllum Weissii* ‡ from

* "Abdr. und Verstein. d. Zwickauer Schwarzk.," p. 36, pl. xi, figs. 5, 5a.
† "Flore foss. bassin houil. de Valenciennes," p. 100, pl. viii, figs. 1–3.
‡ "Traité de paléont. végét.," vol. i, p. 415, pl. xxviii, fig. 7.

Sarrbrück, has been re-examined by SOLMS-LAUBACH, who says "its sporangia are unknown, and I have been unable to satisfy myself from the specimens in the Museum at Strassburg that the character of the sori is as described by the author."* A similar view is expressed by SCHENK.†

The *Hymenophyllites Humboldtii* Göppert ‡ from Waldenburg and the *Trichomanites Beinerti* of the same author § from Charlottenbrunn, the *Hymenophyllum Waldenburgense* Stur || and the *Hymenophyllum antiquum* Ed. Bureau ¶ also fail to exhibit the necessary characters to warrant their inclusion in the *Hymenophyllaceæ.*

Distribution.—The genus *Hymenophyllites* appears to be restricted to Upper Carboniferous Rocks.

Hymenophyllites Bronni Gutbier sp.

Plate LXIX, figs. 1, 1*a*, 1*b*; text-fig. 18.

1835. *Sphenopteris Bronnii* Gutbier, "Abdr. u. Verstein. d. Zwickauer Schwarzkohl.," p. 37, pl. iv, fig. 11, pl. v, figs. 1, 2.
1845. *Sphenopteris Bronnii* Unger, "Synop. plant. foss.," p. 66.
1848. *Sphenopteris Bronnii* Bronn, "Index palæont.," p. 1167.
1849. *Sphenopteris Bronnii* Gutbier, "Verstein. d. Rothliegenden in Sachsen," p. 10, pl. iii, figs. 6, 6*a*–6*c*.
1855. *Sphenopteris Bronni* Geinitz, "Verstein. Steinkohlenf. in Sachsen," p. 16, pl. xxiii, figs. 15, 16.
1869. *Sphenopteris* (*Cheil.*) *Bronnii* Schimper, "Traité de paléont. végét.," vol. i, p. 384.
1886. *Sphenopteris* (*Hymenophyllites*) *Bronni* Zeiller "Flore foss. bassin houil. de Valenciennes," p. 104, pl. vii, fig. 5.
1835. Cf. *Sphenopteris opposita* Gutbier, *op. cit.*, p. 36, pl. xi, fig. 6.

Description.—Frond quadripinnate. Rachis straight or flexuous, with fine longitudinal striations, and attaining a width of 5 mm. Primary pinnæ alternate, rachis straight or slightly flexuous, smooth, 0·5–1 mm. broad. Secondary pinnæ lanceolate, alternate, rachis slightly flexuous, slender, somewhat oblique to primary rachis. Tertiary pinnæ slightly oblique to parent rachis, narrow-deltoid, contracting gradually from the base to the apex; the larger are 1 cm. long and about 5 mm. broad at the base, free or touching each other laterally; rachis slightly flexuous, winged, and bearing three to four pairs of pinnules. Pinnules alternate, oblique, decurrent, and united to each other at base, those on distal side smaller than those on proximal side; basal proximal pinnule largest and divided into about three lateral sharp-pointed, forwardly directed lobes which are separated by an acute-based

* "Fossil Botany," p. 153.
† "Fossilen Pflanzenreste," p. 37, 1888.
‡ "Syst. fil. foss.," p. 254, pl. xxxi, figs. 1, 2.
§ *Op. cit.*, p. 265, pl. xxxii, fig. 1, 1836.
|| "Culm Flora," *Abhandl. k. k. geol. Reichsanst.*, Band viii, Heft ii, p. 178 (284), pl. xv, fig. 15, 1877.
¶ "Bassin de la Basse Loire" (*Études Gîtes Min. France*), fasc. ii; "Flores fossiles," p. 78, pl. xiii, figs. 4, 4A, 4B; pl. xx, figs. 1, 1A, 1B, 2, 2A, 1914.

sinus; upper pinnules with fewer but similar sharp-pointed teeth; terminal lobe bifid, the two teeth sharp-pointed.

"Fertile pinnules much contracted; sporangia united in groups at the extremities of the lobes" (ZEILLER).

Remarks.—The specimen given on Pl. LXIX, fig. 1, probably shows fragments of some primary pinnæ as indicated by their parallel relationship to each other. Their rachis is almost straight, with a narrow furrow passing up the middle. The secondary pinnæ which spring from these have a slightly flexuous rachis. The tertiary pinnæ might almost be described as narrow-triangular, since they decrease regularly from their broad base to the apex, but they are somewhat inequilateral on account of the proximal pinnules being a little larger than the distal ones. This is seen on the tertiary pinna given at fig. 1*b*, which is enlarged six and a half times. The figure also shows the form of the confluent pinnules whose decurrent bases form a wing to the almost straight rachis. The larger basal proximal pinnule has three lateral sharp-pointed lobes, separated by an acute-pointed sinus which extends inwards about half-way to the midrib. The boundary lines to the teeth or lobes are slightly convex. The upper pinnules have fewer but similar teeth, and the terminal lobe of the pinnule is usually bifid, but sometimes consists of a single tooth.

TEXT-FIG. 18. — *Hymenophyllites Bronni* Gutbier sp. *a*, fertile pinna enlarged; *b*, sporangia more highly enlarged; *c*, *d*, pinnules enlarged. From GUTBIER, "Verstein. d. Rothl. in Sachsen," pl. iii, fig. 6, 1849.

The fructification is imperfectly known, and the description of it given in the diagnosis of the species is that taken from ZEILLER (*loc. cit.*). According to GUTBIER (*loc. cit.*) the fructification so alters the pinnules, that instead of the segments, only small globular sporangia, often separated, can be observed (text-fig. 18), while GEINITZ (*loc. cit.*) states that they are not limited to the ends of the segments, but cover the whole upper surface of the pinnule, and only the middle vein is free from them. It seems evident, therefore, that the position held by the sporangia on the pinnules is not clearly understood, nor the minute structure of the sporangia known. Apparently, however, it has come to be provisionally assumed that the sporangia were situated at the apex of the segments, or placed on a special structure which originated from that part of the pinnule-segment, and was possibly comparable to the indusium of *Hymenophyllum*, but there does not appear to be any satisfactory basis for this assumption. It has led, however, to the plant being generally included in the genus *Hymenophyllites*, a most unfortunate generic name, as it infers an affinity which our present knowledge of the plant does not warrant. The structure and arrangement of the sporangia are so imperfectly known that one lacks the necessary characters for any suggestion as to the affinities of *Hymenophyllites Bronni* Gutbier.

BERTRAND * has expressed the opinion that the specimen referred to *Hymenophyllites Bronni*, by ZEILLER,† may be only a form of the *Hymenophyllites quadridactylites* Gutbier, but, as pointed out by ZEILLER, the pinnules in *Hymenophyllites Bronni* have sharp-pointed segments, whereas in *Hymenophyllites quadridactylites* they are obtuse. Through the kindness of the late Prof. ZEILLER I possess a specimen of the latter species from Lens, fosse No. 2, veine Cuvier, which shows most clearly these distinctive characters. There can be no doubt, I think, that the plant given on our Pl. LXIX, fig. 1, is specifically identical with that given by ZEILLER (*loc. cit.*), and both these appear to me to be indistinguishable from the figures given by GUTBIER, which show the teeth of the pinnule to be sharp-pointed, but especially with his figure 6 *a*, pl. iii, of a plant from the Rothliegende of Saxony, which is reproduced here at text-fig. 18 *a*.

Distribution.—I know of one British specimen only of *Hymenophyllites Bronni*, for which I am indebted to Mr W. HEMINGWAY.

WESTPHALIAN SERIES.

YORKSHIRE COALFIELD.

Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley (W. HEMINGWAY).

Hymenophyllites quadridactylites Gutbier sp.

Text-fig. 17 (p. 279).

1835. *Sphenopteris quadridactylites* Gutbier, "Abdr. u. Verstein. d. Żwickauer Schwarzk.," p. 36, pl. xi, figs. 5, 5*a*.
1914. *Sphenopteris* (*Hymenophyllites*) *quadridactylites* Kidston, "Fossil Flora S. Staffordshire Coalfield," *Trans. Roy. Soc. Edin.*, vol. l, p. 85.
1910. *Sphenopteris quadridactylites* Renier, "Documents pour l'étude paléont.," pl. lxvi.
1884. *Hymenophyllites quadridactylites* Kidston, *Quart. Journ. Geol. Soc.*, vol. xl, p. 596 (Refs. in part).
1886. *Hymenophyllites quadridactylites* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 100, pl. viii, figs. 1–3, text-fig. 36, p. 56.
1899. *Hymenophyllites quadridactylites* Potonié, "Lehrb. d. Pflanzenpal.," p. 102, fig. 88.
1900. *Hymenophyllites quadridactylites* Zeiller, "Éléments de paléobot.," p. 68, fig. 37.
1838. *Sphenopteris tetradactyla* Presl in STERNBERG, "Versuch," vol. ii, fasc. vii–viii, p. 128.
1855. *Sphenopteris tridactylites* Geinitz (*non* Brongt.), "Verstein. d. Steinkohlenf. in Sachsen," p. 15, pl. xxiii, figs. 13, 14.
1880. *Sphenopteris delicatula* Zeiller (*non* Sternb.), "Végét. foss. du terr. houil.," p. 42.
1883. *Sphenopteris delicatula* Zeiller (*non* Sternb.), "Fougères du terrain houiller du Nord de la France," *Bull. Soc. Géol. France*, 3^e sér., vol. xii, p. 193.
1883. *Hymenophyllites delicatulus* Zeiller (*non* Sternb.), *Ann. Sci. Nat.*, 6^e sér., Bot., vol. xvi, p. 196; and p. 208, pl. x, figs. 22–32.

Description.—Frond at least quadripinnate and of considerable size. Rachis straight, 2–5 mm. broad, smooth or with very fine longitudinal striations. Primary

* "Liste prov. des *Sphenopteris* du bassin houil. du Nord de la France," *Ann. Soc. géol. du Nord*, vol. xlii, p. 329, 1913.

† "Flore foss. bassin houil. de Valenciennes," pl. vii, fig. 5.

pinnæ free or margins touching, lanceolate, opposite or sub-opposite, 15–20 cm. long and 3–6 cm. broad, slightly oblique to primary rachis, or springing from it at almost right angles, rachis straight. Secondary pinnæ alternate, free or touching laterally, oblong-lanceolate to narrow-deltoid, terminating in a sharp point; rachis straight, departing from the parent rachis at a very wide angle, and attaining a length of 3–5 cm. or more. The basal secondary pinna on the posterior side of the rachis arises from the angle made by the union of the primary pinnæ and main rachis of the frond. Tertiary pinnæ broadly lanceolate, approximate, alternate, or sub-opposite, departing from the rachis at a very obtuse angle, and attaining a length of 8 mm.; rachis straight. Pinnules small, alternate, 2–3 mm. long, of oval contour and divided into 3–5 lobes, that are separated by a sharp-pointed sinus which extends inwards about one-third or more the breadth of the pinnule; lobes blunt-pointed. On the lower and most fully developed tertiary pinnæ the pinnules are approximate, free, and contracted into a stout footstalk; on upper tertiary pinnæ the pinnules are attached by a wide base, decurrent, and united to each other by a wing which borders the rachis. A central straight or slightly flexuous vein enters each pinnule, which gives off a veinlet to each tooth or lobe and extends to its apex.

Fertile segments more narrow than the sterile segments, sporangia ovoid, 0·24 mm. long and 0·15 mm. broad, with a transverse annulus, slightly contracted at the base into a short pedicel, occurring in groups at the extremities of the lobes, or they may have been attached to a prolongation of the vein.

Remarks.—Excellent specimens of this species have been figured by Zeiller,* and the above description is chiefly drawn up from his account of the plant, and from a specimen received from him.

The only British specimen of *Hymenophyllites quadridactylites* which I have yet met with is a small example kindly given me by Mr H. W. Hughes, F.G.S. It is contained in a brown-coloured ironstone nodule on which the plant is represented in a darker shade of brown. Though the specimen does not lend itself to photographic reproduction, the form of the pinnules and their segmentation can be clearly seen and agree well with those of the specimen received from the late Prof. Zeiller, though the segments of the pinnules on our example are somewhat more acute than on the French specimen. The difference is too slight, however, for a possible separation of the two plants. Remarks on the fertile condition have already been made in dealing with the genus *Hymenophyllites.*

Hymenophyllites quadridactylites Gutbier sp. is closely related to *Hymenophyllites Bronni* Gutbier sp., but in the latter species the ultimate pinnæ contract more regularly from the base to the apex, and the pinnule segments are more spreading and terminate in sharp points.

Bertrand holds the view that the plant figured by Zeiller under the name of *Sphenopteris* (*Hymenophyllites*) *Bronni* † is only a form of *Hymenophyllites*

* "Flore foss. bassin houil. de Valenciennes," pl. viii.

† *Ibid.*, pl. vii, fig. 5.

quadridactylites,* but it appears to me clearly to differ from that species in its sharp-pointed and more spreading pinnule segments, and to agree completely with the figures of *Hymenophyllites Bronni* given by GUTBIER and GEINITZ.

Distribution.—Very rare. I know of only one specimen from the undernoted locality.

WESTPHALIAN SERIES.

SOUTH STAFFORDSHIRE COALFIELD.

Horizon: Ten-foot Ironstone Measures. *Locality:* Clayscroft openwork, Coseley, near Dudley. Collected by Mr H. W. HUGHES (Kidston Collection, No. 3565).

Genus **Oligocarpia** Göppert.

1841. *Oligocarpia* Göpp., " Gatt. d. Foss. Pflanzen," Lief. i, ii, p. 3.
1869. *Oligocarpia* Schimper, " Traité de paléont. végét.," vol. i, p. 585.
1883. *Oligocarpia* Zeiller, *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, p. 190.
1883. *Oligocarpia* Stur, " Morph. u. Syst. der Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 686 (54).
1883. *Oligocarpia* Renault, " Cours de bot. foss.," vol. iii, p. 67.
1888. *Oligocarpia* Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 53.
1911. *Oligocarpia* Kidston, " Végét. houil. Hainaut Belge," *Mém. Musée roy. d'Hist. nat. de Belgique*, vol. iv, p. 35.

Description.—Synangia circular, formed of three to five (rarely six) pyriform sporangia with a prominent annulus composed of two rows of cells, which passes over the apex of the sporangia and bends down the sides of their free portion. A band of small narrow cells forming a stomium passes down the ventral surface of the sporangia and indicates the part at which the sporangia opened for the dehiscence of the spores. Spores tetrahedrally developed, smooth, with a triradiate ridge on their surface. The synangia are placed singly on the lateral veinlets, and frequently occupy almost the whole of the limb between the midvein and the margin of the somewhat reduced pinnule, or are situated more towards the margin. The veinlet on which the synangia are placed does not extend beyond them.

Remarks.—The generic characters are drawn up from beautifully preserved fertile specimens of *Oligocarpia Gutbieri* Göpp., the type of the genus.

In all the descriptions of the genus which I have been able to consult, the annulus is described as formed of a single row of cells, but when the sporangia forming the synangia are examined in a suitable position it is seen to be composed of two rows of cells.

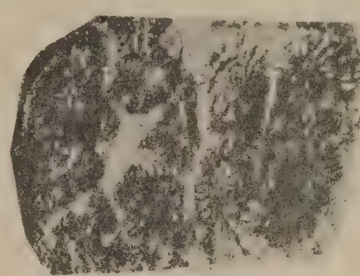
The only other species of *Oligocarpia* known to occur in Britain is *Oligocarpia Brongniarti* Stur, but all our specimens which can be referred with certainty to that species are sterile, or the sporangia are imperfectly preserved. In *Oligocarpia Brongniarti* a greater number of sporangia enter into the sporangial groups than are found in those of *Oligocarpia Gutbieri*. According to ZEILLER the fronds are often loaded with fructification, especially towards the extremity of the pinnæ, though

* BERTRAND, " Liste provisoire des *Sphenopteris* du bassin houil. du Nord de la France," *Ann. Soc. géol. du Nord*, vol. xlii, p. 329, 1913.

sometimes on almost their whole length. Sporangia pyriform, from 0·30 mm. to 0·35 mm. long and 0·16 mm. to 0·20 mm. broad, provided with a transverse annulus, more or less oblique, attached to the number of six to ten, on an average, to the extremities of the veins; some spread out flat on the limb, rose-like, from a half to two-thirds of a millimetre in diameter; others sometimes stand upright from the centre of the group. He also describes the annulus as formed of a single row of cells.*

One can easily understand that in a compressed condition, the annulus might appear to be formed of a single row of cells, for on account of its being placed at the apical margin of the sporangium (see Pl. LXX, figs. 1*c* and 1*d*), pressure acting on the more or less globular structure might cause the fold formed during the process of flattening to pass longitudinally between the two rows of cells forming the annulus when one row would be bent underneath, while the other row of cells would form the apical margin of the sporangia.

Zeiller's figures show the sporangia to possess an annulus of a single row of cells, but from the photographs of the fructification of *Oligocarpia Brongniarti* given by Depape and Carpentier in the "Revue Générale de Botanique," vol. xxvii, pl. ix, figs. 8, 9, I rather think the annulus of this species must also have consisted of two rows of cells. The arrangement of the sporangia is similar to that of *Oligocarpia Gutbieri*, though the groups contain a greater number, but probably the fructification was also a synangium. One cannot, however, speak decisively on this latter point from a surface examination of the fructification of *Oligocarpia Brongniarti*. (See text-fig. 19.)



Text-fig. 19.—*Oligocarpia Brongniarti* Stur. From Depape and Carpentier, *Revue Générale de Botanique*, vol. xxvii, pl. ix, fig. 9. Enlarged.

It has been presumed by several botanists that the arrangement of the sporangia in *Oligocarpia* indicated a more or less close relationship with the *Gleicheniaceæ*, but the double row of cells on the annulus and the synangial structure of the fructification seems to preclude the possibility of the suggested relationship.

As an annulate synangium is a type of fructification unknown to occur in any existing pteridophyte, I do not attempt to assign a definite position to the genus *Oligocarpia*, but leave it an open question.

Distribution.—The genus has been recorded only from the Westphalian Series.

Oligocarpia Gutbieri Göppert.

Plate LXX, figs. 1–3; Plate LXXV, figs. 1, 2.

1841. *Oligocarpia Gutbieri* Göppert, "Gatt. der foss. Pflanzen," Lief. i, ii, p. 3, pl. iv, figs. 1, 2.
1855. *Oligocarpia Gutbieri* Geinitz, "Verstein. d. Steinkohlenf. in Sachsen," p. 30, pl. xxxiii, figs. 6, 7; pl. xxxv, fig. 9.

* "Flore foss. bassin houil. de Valenciennes," p. 53.

1869. *Oligocarpia Gutbieri* Schimper, "Traité de paléont. végét.," vol. i, p. 586, pl. xli, figs. 8, 9.
1877. *Oligocarpia Gutbieri* Stur, "Culm Flora," *Abhandl. k. k. geol. Reichsanst.*, Band viii, Heft 2, p. 309, text-fig. 31.
1879. *Oligocarpia Gutbieri* Lesquereux, "Coal Flora," vol. i, p. 266, pl. xlviii, figs. 1–3.
1883. *Oligocarpia Gutbieri* Stur, "Morph. u. Syst. der Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 687 (55), text-fig. 14.
1885. *Oligocarpia Gutbieri* Stur, "Carbon-Flora der Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 128.
1888. *Oligocarpia Gutbieri* Toula, "Steinkohlen," p. 192, pl. ii, figs. 21, 22.
1899. *Oligocarpia Gutbieri* Potonié, "Lehrb. der Pflanzenpal.," p. 102, fig. 87, iii (p. 101).
1900. *Oligocarpia Gutbieri* Zeiller, "Éléments de paléobot.," p. 69, fig. 39A.

Description.—Frond tripinnate, rachis smooth. Primary pinnæ lanceolate, widest towards centre, slightly contracted at base and tapering to a blunt point; rachis slender, smooth, slightly flexuous, and provided with an aphlebia at point of departure from main rachis. Secondary pinnæ alternate, lanceolate, gradually narrowing from the base and ending in a blunt point, usually free, more rarely their margins touch; the larger secondary pinnæ bear from 8–13 pairs of pinnules. Pinnules attached by a wide base with delicate lamina, broadly oval, slightly contracted at base, with very slight, blunt lobes or a sinuous margin and blunt apex, free or confluent, and forming a narrow wing to the rachis; the smaller and upper pinnules have a wide attachment to the rachis with slight, blunt lobes or sinuous margins; the uppermost are confluent and united to each other for the greater part of their length. Nervation consists of a central vein which gives off dichotomously divided veinlets to the lobes in the larger pinnules and simple veinlets to the smaller ones. An aphlebia is placed on the main rachis at the point of departure of the primary pinnæ, and consists of a flat axis which gives off alternate, flat, dichotomously divided segments which terminate in sharp points.

Synangia circular, arranged in flat rose-like structures, formed of from three to five (very rarely six) pyriform sporangia about 0·45 mm. long, with a prominent annulus which extends across their apical margin, composed of two rows of somewhat elongated cells that are two to three times larger than those of the sporangial wall, and a stomium of very small, narrow, elongated cells which forms a band down the centre of the ventral surface of the sporangia. Spores very numerous, subcircular, smooth, with a triradiate ridge on their surface, $30\,\mu$ to $36\,\mu$ in diameter. The veinlet bearing the synangium terminates beneath it.

Remarks.—Sterile pinnæ of *Oligocarpia Gutbieri* Göpp. are given on Pl. LXX, figs. 2, 3, and Pl. LXXV, figs. 1, 2. That given at fig. 1, Pl. LXXV, probably shows part of a primary pinna. The rachis is slender, about 0·75 mm. broad, smooth and almost straight. The secondary pinnæ are alternate, linear-lanceolate, about 3 cm. long, and their rachis is slightly flexuous. They form a very wide angle at their departure from the primary rachis, are approximate, and occasionally touch each other laterally. The larger pinnæ must have borne 8–10 pairs of pinnules. The pinnules are free, alternate, oval, slightly oblique, contracted at base, with generally a basal blunt lobe on each side, and occasionally two other slight lobes above them and attached by a wide footstalk. The upper pinnules and those on the upper secondary pinnæ are generally trilobate, but the lobes are often feebly pronounced and the margin has simply a sinuous outline. This specimen is very similar to that given by GEINITZ on his pl. xxxv, fig. 9 (*loc. cit.*).

A small fragment of the terminal portion of a pinna is given enlarged two times at fig. 2, Pl. LXXV. This pinna probably held a higher position on the frond than that seen at fig. 1 of the same plate. The pinnules are smaller with less prominent lobes or almost entire, decurrent, and are attached by a very broad base, and the rachis has a narrow wing.

The portion of another sterile pinna, seen at fig. 2, Pl. LXX, may have sprung from the rachis beside which it lies, though possibly its position in relation to it is accidental. It is enlarged two times at fig. 2*a*. The ultimate pinnæ are very short, lanceolate, the pinnules decurrent and all more or less united to each other. They can scarcely be described as lobed, but have a slightly sinuous margin. Two of the pinnules are enlarged at figs. 2*b* and 2*c* to show their form and nervation.

The aphlebiæ attached to the main rachis at the departure of the primary pinnæ are large and much divided. At the base of the rachis of the specimen seen at fig. 3, one sends out segments, both upwards and downwards, which, though imperfect in their upper portion, are 1·5 cm. long. They consist of a flattened axis which gives off similarly flattened pinnate segments. A fragment of one of these aphlebiæ, which occurs on the specimen given natural size at fig. 3, is enlarged three and a half times at fig. 3*a*.

I am indebted to the late Mr P. WHALLEY for some excellent fertile specimens of *Oligocarpia Gutbieri*, two of which are given on Pl. LXX at figs. 1 and 3. That at fig. 1 shows fragments of what I presume to be two primary pinnæ which have evidently arisen from the same rachis. A slight reduction appears to have taken place in the limb of the pinnules, which are almost entire and of a somewhat similar form to those seen at fig. 2*a*. They are decurrent, and their united bases form a broad wing to the slightly flexuous rachis. One of the primary pinnæ of this specimen is enlarged two times at fig. 1*a*. On the secondary pinnæ at the base only a few of the pinnules bear synangia, but above this point, except at the apex of the pinnæ, all the pinnules are fertile though some bear only one, others two, while a few have three synangia. Part of a secondary pinna is enlarged ten times at fig. 1*b* to show their distribution. The uppermost synangium is composed of three sporangia, some of four, and others, especially towards the lower end of the figure, of five sporangia. At fig. 1*c* a few synangia are enlarged twenty-three times, where the annulus is seen to form a prominent object. At fig. 1*d* a single synangium is enlarged fifty times. Owing to the elevation and depression of the various parts of the structure it is impossible to have the whole object in focus at one time, but it shows the annulus to be composed of two rows of cells, and shows also a distinct stomium at right angles to the annulus, marking the place where the sporangia opened for the dissemination of the spores.

Some synangia, from specimens collected by Mr H. H. Thomas, were macerated. Having previously been covered with a layer of balsam, they were washed in benzole, since the balsam prevented the macerating solution from acting on them, but the benzole had not been sufficiently long applied to remove the balsam from the tissue forming the common wall uniting the sporangia, with the result that a preparation was obtained which showed the cellular tissue that lay between the spore-cavities and united them together into a synangium. Fig. 1*e*, enlarged seventy-five times, shows three spore-masses still united by the connecting tissue, and fig. 1*f*, enlarged two hundred and fifty times, shows the connecting tissue which forms the common wall of the spore-cavities and unites them into a synangium. The dark parts of the figure lying on each side of the connecting tissue are parts of two spore-masses. The lighter band between them, which widens from within outwards, exhibits the cells of the mutual wall that lies between the spore-cavities. The width of this dividing wall varies from one cell at the inner margin to several cells in thickness where it fills up the outer angle. The veinlet on which the synangium is placed terminates beneath it.

The sporangial organs seen on *Oligocarpia Gutbieri*, consisting of an annulate synangium, show a type of fructification quite unknown among existing pteridophytes.*

The spores contained in each spore-mass are very numerous, and two are shown enlarged five hundred times at fig. 1*g*. They are circular or subcircular, have a smooth outer surface marked with a triradiate ridge.

The form and arrangement of the synangia, as well as the segmentation and nervation of the sterile pinnules, afford distinctive characters for identifying the species.

Distribution.—*Oligocarpia Gutbieri* Göpp. is a rare British species. It has been recorded from the base of the Staffordian Series and from the Westphalian Series.

STAFFORDIAN SERIES.

Lancashire Coalfield.

BLACKBAND GROUP.

Horizon: From between 24 feet to 321 feet above Bradford Four-foot Coal. *Locality:* Bradford Colliery Sinking, Manchester (P. Whalley).

WESTPHALIAN SERIES.

North Wales Coalfield.

Horizon: From between 116 feet to 192 feet from surface. New Gresford Colliery, 2 miles north of Wrexham, Denbighshire (H. Hamshaw Thomas).

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley (W. Hemingway).

* In *Sturiella intermedia* Renault sp. there is also an annulate synangium, but the sporangia are only united to each other by their bases. See Renault, *Cours de botan. foss.*, vol. iii, p. 122. (*Recopteris intermedia*) Stur, *Morph. u. Syst. der Culm- u. Carbonfarne*, p. 759 (127). (*Renaultia intermedia*) Weiss, *Neues Jahrb. f. Min.*, 1885, I, Refer., p. 492. (*Sturiella*) Scott, *Studies in Fossil Botany*, 3rd ed., vol. i, p. 260, 1920.

Oligocarpia Brongniarti Stur.

Plate LXIX, figs. 2, 2*a*, 3, 3*a* ; text-fig. 19 (p. 285).

1883. *Oligocarpia Brongniarti* Stur, " Morph. u. Syst. der Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 688 (56), fig. 16.
1885. *Oligocarpia Brongniarti* Stur, " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 131, pl. lvii, figs. 2, 3 ; text-fig. 20, p. 129 (Excl. syn.).
1886. *Sphenopteris* (*Oligocarpia*) *Brongniarti* Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 97, pl. xi, figs. 3–5 ; text-fig. 35A, B, p. 54.
1888. *Oligocarpia Brongniarti* Toula, " Steinkohlen," p. 192, pl. ii, figs. 23–25.
1899. *Oligocarpia Brongniarti* Potonié, " Lehrb. d. Pflanzenpal.," p. 101, fig. 87, 1A, B, C.
1910. *Oligocarpia Brongniarti* Renier, " Documents pour l'étude paléontologie," pl. lxi.
1915. *Oligocarpia Brongniarti* Depape and Carpentier, *Revue générale de botan.*, vol. xxvii, pp. 332, 335, pl. ix, figs. 8, 9.
1883. *Sphenopteris* (*Oligocarpia*) *formosa* Zeiller (*non* Gutbier), *Ann. Sci. Nat.*, sér. 6e, Bot., vol. xvi, pp. 190, 191, pl. x, figs. 6–12.
1871. *Sphenopteris splendens* Dawson, " Foss. Plants Devon. and Up. Silur. Form.," *Geol. Survey of Canada*, p. 53, pl. xvi, fig. 186, 186*a*.
1914. *Oligocarpia splendens* Stopes, " The ' Fern Ledges ' Carboniferous Flora of St. John, New Brunswick," *Geol. Survey of Canada, Mem.* 41, p. 40, pl. x, fig. 24, text-fig. 4.

Description.—Frond quadripinnate. Rachis of primary pinnæ flexuous, sometimes showing a cord-like band running up the middle, punctate, and bearing an aphlebia at the insertion of each of the primary pinnæ. Aphlebiæ divided nearly to the base into several narrow linear segments. Secondary pinnæ alternate, distant, linear-lanceolate, slightly narrowed at the base, rachis straight or sub-flexuous, punctate. Tertiary pinnæ alternate, lanceolate, rachis straight or sub-flexuous, winged. Pinnules alternate, separate, or touching by their margins, and slightly decurrent, oblong, and divided into 2–5 pairs of lobes, which are separated by a shallow sinus ; lobes truncate, notched, or ending in a small blunt point, terminal lobe generally bifid. Nervation consists of a central flexuous vein which gives off a veinlet to each lobe, where it divides 2–4 times and provides a veinlet to each tooth.

Fructification often plentifully produced, especially towards the extremity of the pinnæ, though sometimes the pinnæ are fertile throughout their whole length. Sporangia pyriform, from 0·30 mm. to 0·35 mm. long, and 0·16 mm. to 0·20 mm. broad, provided with a more or less oblique transverse annulus composed of (?) two rows of cells. Sori (or synangia ?) formed of a varying number of pyriform sporangia, attached by their narrow base to the extremity of the vein, in number most commonly five or six, which spread out on the limb around a common point of attachment. When there are a greater number of sporangia, the others stand erect from the centre and thus form a sorus (or synangium ?) of a somewhat hemispherical form.

Remarks.—A fragment of a primary pinna or upper portion of a frond is given on Pl. LXIX, fig. 3, natural size, which shows the flexuous rachis with a cord-like band passing up the middle, and the lower portion of a few penultimate pinnæ.

The basal alternate secondary pinnæ, as figured by ZEILLER (*loc. cit.*), are slightly shorter than those placed above them, but on our specimen the difference in their size does not seem to be so much pronounced. The lower half of the ultimate pinnæ is of almost equal breadth, but towards their centre they gradually narrow and terminate in a somewhat blunt point.

Two pinnules are enlarged six times at figures 2*a* and 3*a* to show their segmentation and nervation. The lobes are separated by a shallow sinus which extends inwards rather less than one-third the width of the pinnule. The lobes have generally 2–3 small, rather blunt teeth. When only two teeth are present they are usually of the same height and separated by a sinus, which gives the lobe a truncate appearance.

The slightly flexuous central vein gives off to each lobe at an open angle, a veinlet which dichotomizes 1–3 times according to the number of the teeth of the lobe, to each of which it supplies a veinlet.

Fertile specimens of *Oligocarpia Brongniarti* Stur have been described by Stur (*loc. cit.*), Zeiller (*loc. cit.*), and Depape and Carpentier (*loc. cit.*). Zeiller describes the annulus as composed of a single row of cells, but the figure 9 (*loc. cit.*) given by Depape and Carpentier seems to show the annulus to have at least two rows of cells (text-fig. 19, see p. 285). Whether the sporangia of *Oligocarpia Brongniarti* formed a sorus or a synangium as in *Oligocarpia Gutbieri* has not, however, been determined.

In the general form of the sterile pinnules and their segmentation *Sphyropteris obliqua* Marrat sp. * has a slight similarity to *Oligocarpia Brongniarti*, but the pinnules are smaller and broader in proportion to their length and are not so prominently toothed as those of *Oligocarpia Brongniarti*. The fructification also is essentially distinct.

The sterile condition of *Renaultia chærophylloides* Brongt. sp. has also some likeness to that of *Oligocarpia Brongniarti*, but in the former species the pinnules are usually larger and the pointed teeth are directed forwards.

Dr Stopes in her " 'Fern Ledges' Carboniferous Flora " points out that *Oligocarpia Brongniarti* is specifically identifiable with Dawson's *Sphenopteris splendens* (*loc. cit.*), and by the law of priority Dawson's name should supersede that of Stur. As, however, it is only by means of the new illustrations given by Dr Stopes (1914) that one has been enabled to recognize the identity of *Sphenopteris splendens* Dawson with *Oligocarpia Brongniarti* Stur, I retain the specific name of *Brongniarti* for the species.

Distribution.—Oligocarpia Brongniarti is a very rare British species, and has only been met with in the Westphalian Series.

WESTPHALIAN SERIES.

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Localities:* Woolley Colliery, Darton, near Barnsley (W. Hemingway). Moncknon Main Colliery, near Barnsley (W. Hemingway).

* *Sphenopteris obliqua* Marrat in Higgins, *Proc. Liverpool Geol. Soc.*, Session 13, 1871–72, p. 99, pl. ix, fig. 3.

FOREST OF WYRE COALFIELD.

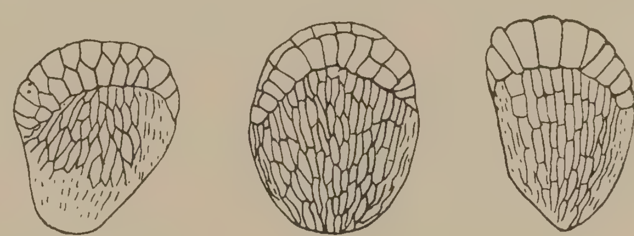
Horizon: Brooch Coal. *Locality:* Highley Colliery, Highley, Shropshire (Collection of Geological Survey, London).

Genus **Boweria** Kidston.

1911. *Boweria* Kidston, "Végét. houil. Hainaut Belge," *Mém. Mus. roy. d'Hist. nat. de Belgique,* vol. iv, p. 31, text-figs. 5 and 6.

Description.—Sporangia annulate, circular or oval, free, one situated on each veinlet at the margin of the pinnule segments, and attaining a diameter of about 0·50 mm. in their greater diameter. Annulus formed of two rows of prominent cells which pass as a band across the apex of the sporangium, and extend a very short distance down the sides. Limb of fertile pinnules slightly reduced.

Remarks.—Under the name of *Hapalopteris Schatzlarensis,* Stur included two species,* that on his pl. xl, fig. 1, being specifically distinct from the other specimens included under the name. For this specimen, his pl. xl, fig. 1, the genus *Boweria* has been created.



TEXT-FIG. 20. — *Boweria Schatzlarensis* Kidston. Sporangia enlarged about 50 times. A, from Clifton, Lancashire; B, C, from Monckton Main Colliery, near Barnsley.

I am indebted to Mr W. HEMINGWAY for some fine fertile specimens of *Boweria Schatzlarensis* Kidston, which show that the sporangia are provided with a prominent annulus. On the first fertile specimens of *Boweria* which came under my observation, the structure of the sporangia was not well preserved, and in error I mistook the plant for a *Renaultia.* In *Renaultia* the sporangia are exannulate and have a tendency to arrange themselves in small groups, though single sporangia also occur at the ends of the veinlets. On *Boweria* the sporangia are always placed singly at the extremities of the veins and occupy the extreme point of the segments of the pinnules. They never seem to form groups. The sporangia are, however, so closely placed that they sometimes touch each other, and thus occasionally seem to form an interrupted border to the pinnule. When the sporangia of *Boweria* are imperfectly preserved and fail to show their minute structure, it is very difficult to separate them from those of *Renaultia,* if even possible to do so with certainty.

Three sporangia of *Boweria* are shown in text-fig. 20. On that at A, the oblique position of the sporangium in the matrix allows the annulus to be examined as seen from above. Here the two rows of cells forming the annulus are clearly seen, and

* "Carbon-Flora der Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 58, pl. xxxix, figs. 7, 7*a*; pl. xl, figs. 1–6.

on account of their greater size they stand out very prominently from the smaller elongated cells of the sporangial wall. At B is seen another example where the annulus is partially hidden underneath. There is also an irregularity in the size of the cells of the annulus, those at the right-hand end being smaller and quadrate in form. Perhaps the annulus at this part consisted of more than two rows of cells. The sporangium seen at C illustrates another position of view. The cells of the annulus are longer than those seen in the other figures, but possibly these larger cells may have been divided by transverse walls which have disappeared, or the second row of cells may be hidden by those which are exposed to view; but anyone judging the structure of the annulus from this specimen alone, might well regard it as composed of a single row of cells, which we know from the examination of other sporangia of *Boweria* is not their normal condition.

The sporangia of *Boweria* are similar in structure to those frequently found in the Coal-balls of Yorkshire and Lancashire, to which Dr Scott gave the name of *Pteridotheca*.* These sporangia, with their annulus formed of two rows of cells, differ from the sporangia of any known existing fern, where the annulus is always formed of a single row of cells. In regard to these Carboniferous sporangia, Dr Scott remarks, "This was perhaps a general character of the annulate Fern-Sporangia of Palæozoic age; at least no clear case of a uniseriate annulus has yet been demonstrated." †

As the value of the presence or absence of an annulus on sporangia as a means of distinguishing Fern sporangia from those of Pteridosperms has been already discussed, the subject need not be considered here.‡

The plants included in the genus may possibly be referable to Ferns.

Distribution.—The genus *Boweria* has hitherto been recorded only from the Westphalian Series in the form of incrustations, but similarly formed sporangia are frequently found as petrifactions in Coal-balls of Lanarkian age.

Boweria Schatzlarensis Kidston.

Pl. LXXI, figs. 1–6; text-fig. 20 (p. 291).

1869. *Sphenopteris Bronni* Roehl (*non* Gutbier), "Foss. Flora d. Steink.-Formation Westphalens," *Palæontographica*, Band xviii, p. 57, pl. xvi, fig. 5A, 5A*a*.

1885. *Hapalopteris Schatzlarensis* Stur (*pars.*), "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 58, pl. xl, fig. 1 (*non* figs. 2–6; pl. xxxix, figs. 7, 7*a*).

1911. *Boweria Schatzlarensis* Kidston (*pars.*), "Végét. houil. Hainaut Belge," *Mém. Musée roy. d'Hist. nat. Belgique*, vol. iv, pp. 30 and 34, text-figs. 5, 6.

1914. *Boweria Schatzlarensis* Kidston, "Fossil Flora South Staffordshire Coalfield," *Trans. Roy. Soc. Edin.*, vol. l, p. 90.

1890. *Renaultia Schatzlarensis* Kidston (*Hapalopteris Schatzlarensis* Stur, *pars.*), "The Yorkshire Carboniferous Flora," *Trans. Yorks. Nat. Union*, pt. 14, p. 32.

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* Scott, *Progressus rei botanicæ*, vol. i, p. 183, 1906; see also Scott, "Studies in Fossil Botany," 3rd ed., vol. i, p. 265, 1920.

† *Loc. cit., Progressus*, p. 184.

‡ See *ante*, p. 278.

Description.—Frond tripinnate, rachis straight, 5 mm. or more broad, smooth. Primary pinnæ alternate, lanceolate, free or touching laterally, rachis slender, about 1 mm. broad, straight or slightly flexuous. Secondary pinnæ; rachis straight, narrowly winged, oblong-lanceolate, free or touching laterally, alternate, the larger 2–2·5 cm. long, and bearing 8–10 pairs of pinnules. Sterile pinnules of broadly lanceolate contour, the larger 5–6 mm. long, contracted at base into a broad point of attachment, oblique to rachis, slightly decurrent, and having three pairs of forward directed lobes or teeth; lobes simple or divided into two teeth which contract at the apex into a sharp point, or are emarginate with a shallow sinus separating the teeth; smaller and upper pinnules with fewer lobes of similar form. The more or less flexuous midrib gives off a simple or dichotomously divided veinlet to each lobe or tooth.

Fertile ultimate pinnæ more narrow than the sterile ones, lanceolate, acute, rachis straight or slightly flexuous, broadly winged; pinnules alternate, limb somewhat reduced, segments narrow, obtuse. Sporangia marginal, each placed at the extremity of a veinlet, oval, about 0·5 mm. in greater diameter, with a prominent annulus composed of two rows of cells which passes across the top and extends a short distance down the sides. Spores subcircular, 40 μ in diameter, and bear on their surface a triradiate ridge.

Remarks.—The type of *Boweria Schatzlarensis* is the specimen given by Stur on pl. xl, fig. 1, of the "Carbon-Flora," under the name of *Hapalopteris Schatzlarensis*, which is specifically distinct from the other specimens he includes under the same name.

In *Boweria Schatzlarensis* the pinnules are larger, the segments are broader, with convex sides, and are separated by a sinus which extends inwards about midway from the margin. In *Sphenopteris* (*Hapalopteris*) *Schatzlarensis* Stur, in addition to the pinnules and their segments being much smaller, the latter are bounded by almost straight lines. These differences will be clearly seen if the figures of *Boweria Schatzlarensis* given on Pl. LXXI, figs. 1, 1*a*, 1*b*, 2, and 2*a* be compared with the corresponding figures of *Sphenopteris Schatzlarensis* Stur sp. seen on Pl. XXX, figs. 1 and 1*a*, and Pl. XXIX, fig. 4. The latter is a much more slender plant than *Boweria Schatzlarensis* and has a more lax type of growth.

A fertile specimen of *Boweria Schatzlarensis* is given on Pl. LXXI, fig. 3, natural size. The ultimate pinnæ are more narrowly lanceolate than the sterile ones, taper gradually from the base and have a broad wing to the rachis, whereas the sterile ultimate pinnæ are oblong-lanceolate. The limb of the pinnules is slightly reduced, and the segments are more narrow and obtuse, and each segment usually bears a single sporangium placed at the extremity of the veinlet.

The sporangia are oval, and measure about 0·5 mm. in their greater diameter. The annulus consists of two rows of cells which are much larger than the vertically elongated cells of the sporangial wall. Fig. 3*a* shows a fertile ultimate pinna enlarged ten times; one of the pinnules from this pinna is given enlarged twenty-five times at fig. 3*b*, where the form of the sporangium and annulus can be clearly seen. The outline drawings given at text-fig. 20 show more distinctly the structure of the sporangia. The number of sporangia on the lower pinnules varies from five to seven, but the uppermost smaller pinnules only bear one to three sporangia.

Spores were obtained from some sporangia by the maceration process, but they were scarcely fully developed. These are, however, shown at fig. 5, Pl. LXXI, enlarged five hundred times. They are subcircular, possess apparently a smooth surface, and have been tetrahedrally developed as shown by the presence of a tri-radiate ridge on their surface. They have a diameter of 40 μ. The spore at the base of fig. 5, towards the centre, illustrates these characters.

Distribution.—Boweria Schatzlarensis is rare in Britain, and has only been recorded from the Westphalian Series.

WESTPHALIAN SERIES.

Forest of Wyre Coalfield.

Horizon: Brooch Coal. *Locality:* Kinlet Colliery, 1 mile south-west of Highley, Shropshire (T. H. Stonehouse).

Lancashire Coalfield.

Horizon: ? *Locality:* Clifton (D. M. S. Watson).

North Staffordshire Coalfield.

Horizon: Below Moss Coal. *Locality:* Lane End, Fenton (Dr W. Hind).

South Staffordshire Coalfield.

Horizon: Ten-foot Ironstone Measures. *Locality:* Clayscroft openwork, Coseley (H. W. Hughes).

Yorkshire Coalfield.

Horizon: Rock over Barnsley Coal. *Locality:* Cooper's Pit, Worsborough Dale, near Barnsley (W. Hemingway).

Horizon: Barnsley Coal. *Localities:* Woolley Colliery, Darton, near Barnsley (W. Hemingway); Monckton Main Colliery, near Barnsley (W. Hemingway); East Gawber Colliery, near Barnsley (W. Hemingway).

Horizon: Below Haigh Moor Coal. *Locality:* Brightside, near Sheffield (W. Hemingway).

Boweria minor Kidston n. sp.

Plate LXXII, figs. 1, 1*a*, 2, 2*a*, 2*b*, 3–7.

Description.—Frond quadripinnate, rachis thick, attaining a breadth of 7 mm., densely apiculate and bearing aphlebia 2 cm. or more in length, which are divided into very narrow linear segments. Primary pinnæ with slender rachis 1 mm. broad, punctate, straight. Secondary pinnæ lanceolate, alternate, slightly overlapping at margins, with slender rachis about 0·25 mm. broad, straight or flexuous. Tertiary pinnæ with very slender, straight, or flexuous rachis, alternate, lanceolate or oblong lanceolate, the larger about 1 cm. long, close, but usually free, and bearing generally three pairs of pinnules. Foliage pinnules alternate, free, small, the basal and larger about 2 mm. long and divided into three very narrow spreading linear segments which end in a blunt point; upper and smaller pinnules bifid or reduced to a single linear segment; terminal pinnule bifid or simple. A simple veinlet enters each segment, but is seldom visible.

Fertile pinnules entirely deprived of the limb. A few sporangia are arranged in groups at the extremities of the ultimate divisions of the frond, apparently free, small, 0·40 mm. to 0·50 mm. in diameter, with a prominent annulus of two rows of cells that passes over the apex and extends slightly down the sides of the sporangium.

Remarks.—Several specimens of *Boweria minor* have been collected by Mr W. Hemingway, but all from one locality and horizon, and possibly from a single block. The frond is much broken up on our specimens, but when perfect must have attained to a fair size, since the rachis is at least 7 mm. broad. Two examples of pieces of rachis are given at figs. 3 and 4. Both show the occurrence of an aphlebia, but the pinnæ from the base of which they have presumably arisen are broken off. A portion of a small slab showing numerous remains of pinnæ bearing the foliage pinnules is shown natural size at fig. 1. The rachises of the penultimate and ultimate pinnæ are very delicate, straight, or slightly flexuous, and the pinnules are very small, few of them exceeding 1 mm. in length, though on the small specimen given at fig. 2 they are about 2 mm. long. At fig. 1*a* a portion of the specimen seen at fig. 1 is enlarged two times to illustrate more clearly the general appearance of the species. The pinnules have been of very delicate texture and many of them are broken and imperfect. Their form is better shown in the small example given at fig. 2, which is enlarged two times at fig. 2*a*. Two pinnules from this example are seen enlarged seven and a half times at fig. 2*b*. A single veinlet enters each segment and terminates in the obtusely rounded apex. On most of the pinnules the apex of one or more of the segments has been broken off or decayed, which causes them to have a truncate appearance, but when perfect they always have obtusely rounded apices. The veins are very seldom seen, but sufficient are preserved to show that each segment or tooth of the pinnule was provided with a single veinlet.

At the point marked *a* on fig. 5 a pinna is seen in circinate vernation in association with other fragments of the species.

The small fertile specimen shown at fig. 6, natural size, occurs in association with some sterile foliage pinnæ. A pinnule limb is entirely absent, and the sporangia are borne at the ends of rachis-like ultimate divisions of the frond. The sporangia seem to be arranged in little groups of four or five at the apices of these ultimate divisions, but they have been so copiously produced and are so small that only in rare cases can one distinguish the small star-like sori. Although the sporangia are so small they are converted into a brittle coaly substance which is easily fractured, and the majority of them are more or less broken.

At fig. 7 two sporangia are enlarged fifty times. That at *a* is lying on and obscures the greater portion of the sporangium lettered *b*, of which only the annulus is exposed. The annulus with its two rows of large cells forms a most prominent object, and stands out very distinctly from the smaller cells, which form the wall of the sporangium.

Were *Boweria minor* known only in the sterile condition it would be placed in the form-genus *Rhodea*, with which, in the form of its foliage-pinnules, it entirely agrees. The structure of its sporangia, however, removes it to the genus *Boweria*.

It is possible that *Boweria minor* may be a fern, but until the systematic value of the presence or absence of an annulus is more fully determined we are scarcely in a position to use that character as a distinguishing feature for the separation of Ferns from Pteridosperms. Its systematic position must therefore remain undecided.

Distribution.—Very rare, and found only once in rocks of Westphalian age.

WESTPHALIAN SERIES.

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley (W. Hemingway).

Genus **Corynepteris** Baily.

1860. *Corynepteris* Baily, " Explanation to Sheet 142, Geol. Survey of Ireland," p. 16, fig. 8.
1860. *Corynepteris* Baily, *Nat. Hist. Review*, vol. vii, p. 258, pl. xiv.
1888. *Corynepteris* Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 41.
1883 (Oct.). *Grand' Eurya* Zeiller, *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, p. 203.
1883 (Dec.). *Saccopteris* Stur, " Morph. u. Syst. d. Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 696 (64) (fig. inaccurate).
1885. *Saccopteris* Stur, " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 159 (fig. inaccurate).
1885. *Grand' Euryella* Weiss, *Neues Jahrb. für Min.*, Band i, p. 492.

Description.—Frond of considerable size, tripinnate. Primary pinnæ linear-lanceolate, arising from the rachis in pairs. Secondary pinnæ linear, long, of almost equal width throughout and bearing many alternate small-toothed pinnules which are generally more or less united to each other, though occasionally they are free. Fertile pinnules similar to sterile or the limb of the pinnules more or less reduced. Sporangia of large size, ovate, sessile, provided with a complete longitudinal annulus formed of several rows of cells that pass up the sides and over the apex of the sporangia. Sorus spherical, composed of from 5–6 sporangia grouped around a common point and touching each other by the edges of their annuli. As the cells of the annulus approach the base they gradually become less differentiated from those of the walls, until they finally assume the same form (see text-fig. 21).

Remarks.—Zeiller * and Bertrand † have shown on good grounds that the genus *Corynepteris* Baily is synonymous with the genus *Zygopteris* Corda.‡ The specimens included in *Corynepteris* show the plant as an incrustation, whereas in *Zygopteris* they occur as a petrifaction in which the original structure of the plant is more or less perfectly preserved.

As the genus *Corynepteris* is reserved for those plants which possess the definite form of sporangia described above, Potonié created the genus *Alloiopteris* § for the reception of those species whose pinnæ and pinnules are of a similar type of build to those of the sterile fronds of *Corynepteris* but whose fructification is unknown.

Most probably the fossils placed in *Alloiopteris* are only sterile examples of members of the genus *Corynepteris,* but until their fructification is known, they cannot be placed in the latter genus.

Distribution.—The genus *Corynepteris* has only been met with in Upper Carboniferous rocks and extends throughout the whole series.

Corynepteris (Zygopteris) coralloides Gutbier sp.

Plate LXIX, fig. 4; Plate LXXIII, figs. 2–5; Plate LXXIV, figs. 4, 4*a*; text-fig. 21, B, B′.

1835. *Sphenopteris coralloides* Gutbier, "Abdr. u. Verstein. d. Zwickauer Schwarzkohl.," p. 40, pl. v, fig. 8.
1845. *Sphenopteris coralloides* Unger, "Synop. plant. foss.," p. 62.
1848. *Sphenopteris coralloides* Bronn, "Index palæont.," p. 1167.
1850. *Sphenopteris coralloides* Unger, "Genera et species," p. 114.
1855. *Sphenopteris coralloides* Geinitz, "Verstein. d. Steinkohlf. in Sachsen," p. 16, pl. xxiii, fig. 17 (named on Plate *Sphenopteris microloba*).
1899. *Sphenopteris coralloides* Hofmann and Ryba, "Leitpflanzen d. Palæoz. Steink.," p. 40, pl. v, fig. 7, 7*a* (not pl. iv, fig. 12).
1886. *Sphenopteris* (*Corynepteris*) *coralloides* Zeiller, "Flore foss. du bassin houil. de Valenciennes," p. 117, pl. x, figs. 1–5.
1910. *Sphenopteris* (*Corynepteris*) *coralloides* Arber, "Fossil Flora of the Yorkshire Coalfield," *Proc. Yorks. Geol. Soc.*, vol. xvii, pt. 2, p. 150, pl. xviii, fig. 3, pl. xix, fig. 2.
1877. *Oligocarpia coralloides* Stur, "Culm Flora," *Abhandl. k. k. geol. Reichsanst.*, Band viii, Heft 2, pp. 293, 306.

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* "Eléments de paléobot.," p. 76, 1900.
† *Comptes rendus*, vol. clviii, p. 740, 1914.
‡ Corda, "Flora d. Vorwelt," p. 81, 1845.
§ "Lehrbuch d. Pflanzenpal.," p. 138, 1899.

1883. *Grand' Eurya coralloides* Zeiller, *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, pp. 206, 209, pl. xii, figs. 1–8.
1883. *Saccopteris coralloides* Stur, " Morph. u. Syst. d. Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 700 (68).
1885. *Saccopteris coralloides* Stur, " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 164.
1891. *Corynepteris coralloides* Kidston, " On the Fructification, etc., of Carboniferous Ferns," *Trans. Geol. Soc. Glasgow*, vol. ix, p. 16, pl. i, fig. 17, 17*a*, 17*b*.
1899. *Corynepteris coralloides* Potonié, " Lehrb. d. Pflanzenpal.," p. 99, fig. 80B and 80B'.
1914. *Corynepteris coralloides* P. Bertrand, " Relations des Empreintes de *Corynepteris* avec les *Zygopteris*," *Comptes rendus Acad. Sci. Paris*, vol. clviii, p. 741.
1914. *Corynepteris coralloides* P. Bertrand, " Quelques *Sphenopteris* du terrain houiller du Nord," *Ann. Soc. géol. du Nord*, vol. xliii, p. 98.
1913. *Alloiopteris* (*Corynepteris*) *coralloides* Gothan, " Oberschlesische Steinkohlenflora," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Band lxxv, Teil i, p. 111, pl. xxv, figs. 1, 3.
1913. *Zygopteris* (*Corynepteris*) *coralloides* P. Bertrand, " Liste provisoire des *Sphenopteris* du bassin houiller du Nord," *Ann. Soc. géol. du Nord*, vol. xlii, p. 320.
1836. *Cheilanthites grypophyllus* Göpp., " Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 242, pl. xxxvi, figs. 1, 2.
1845. *Sphenopteris grypophylla* Unger, " Synop. plant. foss.," p. 62.
1869. *Sphenopteris grypophylla* Schimper, " Traité de paléont. végét.," vol. i, p. 380.
1882. *Sphenopteris grypophylla* Weiss, " Aus der Flora der Steinkohlenformation " (*K. preuss. geol. Landesanst.*), p. 14, pl. xii, fig. 78, 78*a*.
1899. *Alloiopteris grypophylla* Potonié, " Lehrb. d. Pflanzenpal.," p. 139, fig. 133.
1885. *Saccopteris grypophylla* Stur, " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 176, pl. liii, figs. 3, 4, 5.
1913. *Zygopteris* (*Corynepteris*) *grypophylla* P. Bertrand, *op. supra cit.*, p. 321.
1873. *Sphenopteris microphylla* Breton (*non* Gutbier), " Étude géol. du sud de la Concession de Dourges " (Lille), p. 411, pl. v, fig. 4.
1882. *Sphenopteris microloba* Weiss (*non* Göpp.), *op. supra cit.*, p. 14, pl. xii, figs. 79, 79*a* (2nd ed.).
1885. *Saccopteris Crepini* Stur, *op. supra cit.*, p. 174, pl. liii, figs. 1, 2.
1860. Cf. *Corynepteris stellata* Baily, " Explanation to Sheet 142, Geol. Survey of Ireland," p. 16, figs. 8 *a*, *b*, *c*.

Description.—Frond probably of considerable size, tripinnate. Primary pinnæ; rachis straight, thick, attaining a width of 7 mm., smooth, with frequently two vertical lines which divide the rachis into three bands, with fine longitudinal striations and sometimes little hair-like scales or the points from which they have fallen. Secondary pinnæ; rachis straight, alternate, at right angles to primary rachis, more or less distant, linear and of equal width till near the apex, where they contract into a point. A small aphlebia, divided into narrow linear segments, is situated at the base of the pinnæ on the superior side. Tertiary pinnæ alternate, rachis straight, oblong linear, of equal width till near the apex, where they end in a blunt point, reaching a length of 1 cm. and 3 mm. broad, with about seven pairs of pinnules. Pinnules alternate, very small, about 1–1·5 mm. long, decurrent, slightly oblique or almost at right angles to rachis, of rotund contour, contracted at base into a short pedicel and divided into two or three blunt lobes which may each have 2–3 small teeth. Nervation; the median strong vein gives off lateral branches which divide and supply a veinlet to each tooth.

Fertile pinnæ linear, 9 cm. or more long, more distant than the sterile ones; limb of the pinnule reduced and their apical portion prolonged into a few narrow linear segments that extend beyond the sorus, which is situated on the pinnule a short distance above its base. Sorus almost spheroidal, with a diameter of about 1·5 mm. and composed of five to seven sporangia. Sporangia sessile, ovoid, 1 mm. long and 0·5 mm. broad, and provided with an annulus composed of many rows of cells forming a somewhat semicircular band; this band passes up the sides and over the apex of the sporangia, which touch each other laterally, and are often deformed from mutual pressure. (Text-fig. 21, B, B′.)

Forma *grypophylla* Göpp. pro sp.

Pinnules slightly more distant and generally divided in two blunt lobes.

Remarks.—A typical specimen of *Corynepteris coralloides* Gutbier sp. is shown natural size on Pl. LXIX, fig. 4, and a portion is enlarged two times at fig. 4*a* to show the form of the pinnules. These are very small, placed close together, decurrent, generally free but sometimes touching, especially on the upper tertiary pinnæ. It is only on very well preserved examples that the small teeth of the pinnules can be observed, and the pinnules often have the appearance of possessing only three blunt lobes as in our fig. 4*a*, but as figured by ZEILLER * these larger lobes are again toothed. When the specimens are well preserved the nervation stands out prominently, and the veinlets are thick for the size of the pinnule (fig. 4*a*). The aphlebiæ at the base of the secondary pinnæ are not shown on our specimen except perhaps a small fragment of one of them. They seem to have been fugacious and like the scales appear to have been shed at an early period. The rachis often shows two vertical lines, slightly separated from each other, that extend up the rachis. These are believed to represent the two ends of the (——) formed vascular strand of the Zygopteris vascular system. The presence of these two vertical lines, as well as that of the hair-like scales, depends also in great measure on the preservation of the specimen; thus very frequently neither is shown, and the rachis appears to be smooth, though generally the fine longitudinal striations are observable.

TEXT-FIG. 21.—A, *Corynepteris stellata* Baily. Fragment of a fertile pinna, enlarged 2 times. A′. sorus, enlarged 4 times. B, *Corynepteris coralloides* Gutbier sp., fragment of a fertile pinna, enlarged 4 times. B′, sorus, seen from the side, enlarged 30 times. After ZEILLER.

A fertile specimen is seen on Pl. LXXIII, fig. 5, but the sporangia are much crushed and do not show their individual form. On some of the fertile pinnæ the limb extended beyond the sorus, where it is divided into a few very narrow segments. This is seen enlarged ten times at fig. 5*a*.

From the same locality as that from which the fertile example was obtained,

* "Flore foss. bassin houil. de Valenciennes," pl. x, fig. 4A.

several sterile specimens were collected. Some of these are figured on the plates to show intermediate forms of pinnule segmentation which connect the type with the form named *Cheilanthites grypophylla* by GÖPPERT. At fig. 4, Pl. LXXIII, a few pinnules are enlarged ten times; in form these cannot be separated from those of *Corynepteris coralloides*. The small example given natural size on Pl. LXXIV, fig. 4, and enlarged two times at fig. 4*a*, shows a slight disappearance of the typical *Corynepteris coralloides* form of pinnule in the direction of the form *grypophylla*. At fig. 3, Pl. LXXIII, a small form of the species is seen natural size, and enlarged two times at fig. 3*a*. Here the pinnules are more distant and their segments frequently two-lobed. An ultimate pinna is given at fig. 3*b*, enlarged seven times, where the lower pinnules are losing the denser form of those of *Corynepteris coralloides*, and assuming the bifid condition of GÖPPERT'S *Cheilanthites grypophylla*.

The small specimen seen on Pl. LXXIII, fig. 2, shows two fragments of pinnæ lying at a converging angle to each other, and it is possible that they are a portion of two zygopteroid pinnæ which come together at a lower level.

Palæobotanists are now generally of opinion that *Corynepteris grypophylla* Göpp. sp. is only a form of *Corynepteris coralloides* Gutbier, and this view has been expressed by POTONIÉ,* by GOTHAN,† and BERTRAND,‡ but STERZEL believed that they could not be united.§ The evidence for the union of the two species, however, seems so clear that *Corynepteris grypophylla* is here united with *Corynepteris coralloides*.

The *Trichomanites grypophyllus* Göpp.,|| and *Sphenopteris* (*Trichom.*) *grypophylla* Schimper,¶ must not be confused with *Corynepteris* (*Cheilanthites*) *grypophylla* Göpp. sp., as they are specifically and generically distinct.

There can be no doubt that *Corynepteris coralloides* Gutbier sp. belongs to the Zygopterideæ.

Distribution.—*Corynepteris coralloides* is not common in Britain, and has only been recorded from the Westphalian Series.

STAFFORDIAN SERIES.

Horizon: No. 3 Rhondda Seam. *Locality:* Glamorgan Colliery, Gilfach Goch, Glamorganshire (D. DAVIES).**

WESTPHALIAN SERIES.

LANCASHIRE COALFIELD.

Horizon: "Forest Bed." *Locality:* Oldham Edge, Oldham.

Horizon: Ravenhead Coal. *Locality:* Ravenhead, near St Helens ("Ravenhead Collection," Liverpool Museum).

* "Lehrb. d. Pflanzenpal.," p. 99.

† "Oberschlesische Steinkohlenflora," Teil 1, p. 111.

‡ *Ann. Soc. géol. du Nord*, vol. xlii, p. 321.

§ "Paläont. Charakter d. Steink. u. Rothl. von Zwickau," *Erläuter. z. geol. Specialkarte d. Königreichs Sachsen*, Section Zwickau, p. 111, 1901.

|| "Flore foss. d. Uebergangs.," p. 149, pl. xliv, fig. 2, 1852.

¶ "Traité de paléont. végét.," vol. i, p. 413.

** Since the earlier parts of this Memoir were published our knowledge of the flora of this seam has extended, and shows that it must be included in the Staffordian Series.

North Derbyshire and Nottingham Coalfield.

Horizon: Below Waterloo Coal. *Locality:* Newthorp Clay Pit, Eastwood, Nottinghamshire (Dr L. Moysey).

South Wales Coalfield.

Horizon: Black Vein. *Locality:* Risca, Monmouthshire.

Warwickshire Coalfield.

Horizon: Roof of Bench Coal. *Locality:* Stanley Bros. No. 4 Brick Pit, 700 yards south of point where road crosses canal between Stockingford and Nuneaton (Collection of Geological Survey, London).

Corynepteris (Zygopteris) Sternbergi Ettingshausen sp.

Plate LXXIV, figs. 1, 2, 2*a*, 2*b*, 3, 5, 5*a*–5*d*;
Plate LXXVIII, figs. 1, 1*a*, 2.

1854. *Asplenites Sternbergii* Ett., "Steinkohlenflora v. Radnitz," *Abhandl. k. k. geol. Reichsanst.*, Band ii, p. 42, pl. xx, figs. 2, 3, (and part of) 4.
1869. *Pecopteris* (*Asplen.*) *Sternbergii* Schimper, "Traité de paléont. végét.," vol. i, p. 525.
1876. *Pecopteris Sternbergii* Boulay, "Terr. houil. du Nord de la France," p. 32, pl ii, fig. 4.
1877. *Oligocarpia Sternbergii* Stur, "Culm Flora," Heft ii, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 294.
1882. *Sphenopteris Sternbergii* Weiss, "Aus der Flora der Steinkohlenformation" (*K. preuss. geol. Landesanst.*), p. 13, pl. xii, fig. 75 (*Zweiter Abdr.*).
1886. *Sphenopteris Sternbergii* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 128, pl. ix, fig. 5; pl. xxxviii, fig. 6.
1899. *Sphenopteris Sternbergii* Hofmann and Ryba, "Leitpflanzen," p. 40, pl. iv, fig. 13.
1912 *Sphenopteris Sternbergii* Vernon, "Geology and Palæontology of the Warwickshire Coalfield," *Quart. Journ. Geol. Soc.*, vol. lxviii, p. 637, pl. lviii, figs. 3 and 5.
1883. *Saccopteris Sternbergii* Stur, "Morph. u. Syst. d. Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 700 (68).
1899. *Sphenopteris* (*Corynepteris*) *Sternbergi* Zeiller, "Étude sur la flore foss. du bassin houil. d'Héraclée" (*Mém. Soc. géol. France, Paléont.*, xxi), p. 24, pl. ii, figs. 8, 9.
1899. *Alloiopteris Sternbergii* Potonié, "Lehrb. d. Pflanzenpal.," p. 139, fig. 134.
1910. *Alloiopteris Sternbergi* Deltenre and Cambier in Renier, "Documents pour l'étude paléont.," pl. lxxvii, figs. *a*, *b*.
1910. *Alloiopteris* (*Corynepteris*) *Sternbergi* Renier, *Ann. Soc. géol. de Belgique*, vol. xxxvii, Bull. p. B. 249.
1913. *Alloiopteris* (*Corynepteris*) *Sternbergi* Gothan, "Oberschlesische Steinkohlenflora," Teil 1, *Abhandl. k. preuss. geol. Landesanst.*, N.F., Band lxxv, p. 113, pl. xxvi, figs. 2, 2*a*.
1913. *Zygopteris* (*Corynepteris*) *Sternbergi* Bertrand, "Liste provisoire des *Sphenopteris* du Bassin houiller du Nord," *Ann. Soc. géol. du Nord*, vol. xlii, p. 321.
1885. *Saccopteris Essinghii* Stur (*non* Andrae *pars*), "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 166, pl. lii, figs. 3, 4 (? 5).

Description.—Frond tripinnate, and attaining to large size ; rachis 8 mm. broad, outer surface densely apiculate. Primary pinnæ linear-lanceolate, contracted at base and tapering at apex into a sharp point, rachis straight, apiculate, when outer surface destroyed, smooth, with fine longitudinal striations and frequently with two flexuous thread-like strands passing up the axis, or a single broad cord-like band, and bearing thirty or more pairs of secondary pinnæ and an aphlebia which springs from the posterior side and occupies the angle formed by the union of the primary pinnæ with the parent rachis. Secondary pinnæ alternate, linear, those on central region of pinna extending outwards at almost right angles, the basal ones more or less deflexed, of almost equal width, 5 cm. long and 1·5 mm. to 4 mm. broad, generally free and bearing twenty-five or more pairs of pinnules. Pinnules small, alternate, quadrate, acute, sessile, decurrent, with three or four pointed teeth on upper margin, rarely free, usually more or less united to each other, the free portion being separated by a sharp-pointed sinus.

A single vein enters the pinnules obliquely, and gives off alternately a veinlet to each tooth.

Fertile pinnæ are of the same form as the sterile ones. Those at base of primary pinnæ completely covered with sori ; a few of the pinnules at the base of the middle and upper pinnæ remain sterile, but the upper pinnules are all fertile. A single sorus seems to occupy the base of each fertile pinnule. Sporangia 1·5 mm. to 2 mm. long, united in groups to form a sorus, and having a prominent longitudinal annulus formed of several rows of cells, which passes up the two sides and over the top of the sporangium. Spores very numerous, circular, from $55\,\mu$ to $58\,\mu$ in diameter, provided with a triradiate ridge, outer surface papillose.

Remarks.—Only fragments of the frond of *Corynepteris Sternbergi* Ett. sp. are known, and these mostly parts of primary pinnæ. A small piece of a primary pinna attached to the rachis has been figured by Zeiller,* and a similar specimen is given here on Pl. LXXVIII, fig. 1, natural size. This shows portion of the main rachis 4 mm. broad and densely apiculate with blunt little elevations. At the point where the rachis is broken over, the insertion of a primary pinna is seen. In the angle formed by the union of this pinna to the rachis, apparently on the posterior side, an aphlebia is borne. This is seen on fig. 1, but better on fig. 1*a*. The secondary pinnæ at the base of this primary pinna are very short, being only about 0·75 cm. long and proportionally narrow. They are deflected towards the main rachis, and this would appear to be a normal condition, as it is also observable on the example given by Zeiller. As the secondary pinnæ are traced upwards they straighten themselves out, and stand at almost right angles to the rachis, while at the apex of the pinnæ they become directed slightly forward.

On another example † of *Corynepteris Sternbergi*, collected by Mr W. Hemingway from the same locality as that just described, there is a rachis 7 mm. broad. I believe that this originally bore a primary pinna that lies at a natural angle towards

* *Loc. cit.*, pl. xxxviii, fig. 6.

† Kidston Collection, No. 1450.

it, but the point where they probably met is unfortunately broken off. In any case, the breadth of this rachis shows that the fronds must have attained to a large size.

Some secondary pinnæ are given at fig. 2, Pl. LXXIV, natural size. They show their narrow linear form and the small united pinnules, the largest of which are only 2 mm. long. The pinnules are decurrent and more or less united to each other. At figs. 2*a* and 2*b* are seen two pinnules, enlarged six times, which show the varying extent of their union to each other. On the specimen given at fig. 1 the pinnules stand quite free from each other. A pinnule from another example is shown enlarged six times at fig. 3; here the pinnules further show a slight contraction at their base.

The pinnules have usually two or three pointed teeth on their upper margin. The degree of prominence of the teeth varies according to the position of the pinna on the frond which bears them. On some, as figured by ZEILLER,* the teeth are more prominent than those seen on our figs. 2*a*, 2*b*, and 3.

The vein enters the pinnules obliquely, being nearer to the posterior than the anterior margin. It gives off alternate veinlets, one of which goes to each tooth.

The largest specimen of a primary pinna which I have examined is shown natural size at fig. 1, Pl. LXXIV. This incomplete fragment is 19 cm. long and the rachis is 2 mm. broad, and shows a flexuous cord-like strand about 1 mm. broad at its lower end, passing up the rachis. The rachis has lost its outer layer, and it now shows a smooth surface. From the knees of the flexuous central strand alternate pinnæ are given off. It is possible that the broad rachis lying beside this primary pinna may be a portion of the main rachis of the frond. It shows very clearly the two cord-like strands passing up it, which are characteristic of *Corynepteris Sternbergi* and other members of the group.

At fig. 2, Pl. LXXVIII, a small example is enlarged two times to show the central flexuous strand. It is distinctly seen at *a* and above at *b*. At the knees the secondary pinnæ are given off. In this as in the specimen given at fig. 1, Pl. LXXIV, the central strand is a solid cord-like structure, but in some other cases two distinct thread-like bands pass up the rachis of the primary pinna. This is seen clearly on another fragment that occurs on the same small slab as that shown at fig. 1, Pl. LXXVIII, and though it is observable on the latter specimen, it does not come out clearly in the figure.

In describing *Corynepteris* (*Zygopteris*) *coralloides* Gutbier sp.† reference has already been made to the presence of the two thread-like strands which pass up the rachis and which are supposed to represent the two extremities of the (——) shaped vascular bundle. There is little reason to doubt this explanation. When, however, the (——) formed vascular bundle is subject to a certain amount of pressure, the two upright ends of the (——) would most probably be flattened against the connecting

* *Loc. cit.*, pl. xxxviii, figs. 6A, 6B.

† *Ante*, p. 299.

bar, when the vascular bundle would appear as a single broad strand as seen on our fig. 2, Pl. LXXVIII and fig. 1, Pl. LXXIV.

A fertile specimen of *Corynepteris Sternbergi* is given natural size at fig. 5, Pl. LXXIV. The sporangia are much crushed and difficult to observe individually, but they show very well the broad annulus formed of several rows of cells passing up the sides of the sporangia.

Some of the sporangia were macerated and the spores obtained from them. Fig. 5*a*, Pl. LXXIV, shows a complete spore-mass removed from a sporangium and enlarged thirty-three times. It measures about 1·5 mm. long and 0·75 mm. broad. A part of this group of spores enlarged one hundred and five times is given at fig. 5*b*. The spores are extremely numerous, and usually firmly cemented together, presumably by mineral matter, but a few were obtained which had separated from the mass. Two of these are seen at figs. 5*c* and 5*d* enlarged five hundred times. They are circular with a distinct triradiate ridge, and have a fine apiculate or granulate outer surface.

Corynepteris Sternbergi is easily distinguished from *Alloiopteris serrula* Lesqx. sp. and *Alloiopteris Radstockensis* Kidston by the more quadrate form of its pinnules and sharp-pointed teeth, the central one of which usually distinctly extends beyond the others.

Distribution.—Corynepteris Sternbergi Ett. sp. is widely distributed in the Westphalian Series, but is not a common species. In the Lanarkian Series it is very rare, the records from this horizon being mostly founded on the occurrence of a single specimen.

WESTPHALIAN SERIES.

Burnley Coalfield.

Horizon: Arley Mine. *Locality:* Brickwork, Hibson Road at Marsden Height, Nelson, Lancashire (P. Whalley).

Horizon: Shale above Fulledge Thin or Yard Mine. *Locality:* Bank Hall Colliery, Burnley, Lancashire (P. Whalley).

Forest of Wyre Coalfield.

Horizon: Brooch Coal. *Locality:* Kinlet Colliery, 1 mile south-west of Highley, Shropshire (T. H. Stonehouse).

Lancashire Coalfield.

Horizon: "Forest Bed." *Locality:* Oldham Edge, Oldham (J. Nield).

Horizon: Ravenhead Coal. *Locality:* Ravenhead, St Helens (Ravenhead Collection, Liverpool Museum).

North Derbyshire and Nottingham Coalfield.

Horizon: Between Deep Hard and Silkstone Coal. *Locality:* Bondsmain Colliery, Temple Normanton, near Chesterfield (Collection of Geological Survey, London).

Warwickshire Coalfield.

Horizon: Seven-foot Coal. *Locality:* Chilvers Coton Clay Pit, Heath End, Nuneaton (R. D. Vernon).

Horizon: Ryder Coal. *Locality:* Baddesley Colliery, 2 miles W.S.W. of Atherstone (R. D. Vernon).

Yorkshire Coalfield.

Horizon: 46½ feet above Barnsley Coal. *Locality:* Brodsworth Colliery, 4 miles N.W. of Doncaster (H. Culpin).

Horizon: Barnsley Coal. *Localities:* Monckton Main Colliery, near Barnsley (W. Hemingway); South Kirkby Colliery, near Pontefract (W. Hemingway); Mickleton Main Colliery, near Rotherham (W. Gelder); Woolley Colliery, Darton, near Barnsley (W. Hemingway).

LANARKIAN SERIES.

Ayrshire Coalfield.

Horizon: 2 fathoms below Ell Coal. *Locality:* Busbie Pit, Kilmarnock.

Horizon: 17 feet below Five-quarter Coal. *Locality:* Ardeer Pit, Stevenston (J. Smith).

Lanarkshire Coalfield.

Horizon: Kiltongue Coal. *Locality:* Brownrigg Pit, Greengairs, near Airdrie.

Stirlingshire Coalfield.

Horizon: Ball Coal. *Locality:* Meadow Bank Pit, ½ mile south of Polmont.

Genus **Alloiopteris** Potonié.

1899. *Alloiopteris* Potonié, "Lehrbuch der Pflanzenpalæontologie," p. 138.

Description.—Frond tripinnate, of large size. Primary pinnæ alternate, linear-lanceolate. Secondary pinnæ linear, narrow, of almost equal width throughout, usually free and bearing many pairs of pinnules. Pinnules small, alternate, decurrent, usually more or less united to each other and generally bear a few more or less prominent teeth on their apical portion. Fructification unknown.

Remarks.—As already stated when dealing with the genus *Corynepteris*, the fronds placed in *Alloiopteris* are probably the sterile condition of species of that genus, but which, owing to their fructification being unknown, cannot be included in it.

A number of species referable to *Alloiopteris* have been described, but the specific relationship of some of these to each other is not clear.

Distribution.—The genus *Alloiopteris* occurs most frequently in the Westphalian Series, though it is not common; it is very rare in the Radstockian, and is unrecorded from the Lanarkian Series, but one species is found in rocks probably corresponding in age to the Upper Limestone Group of the Carboniferous Limestone Series.

Alloiopteris quercifolia Göppert sp.

1836. *Hymenophyllites quercifolius* Göpp., "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 252, pl. xiv, figs. 1, 2.
1845. *Hymenophyllites quercifolius* Unger, "Synop. plant. foss.," p. 69.
1854. *Hymenophyllites quercifolius* Geinitz, "Flora d. Hainich-Ebersdorfer u. d. Flœhær Kohlen-bassins," p. 41, pl. iii, fig. 4.
1869. *Sphenopteris* (*Hymen.*) *quercifolia* Schimper, "Traité de paléont. végét.," vol. i, p. 403.
1877. *Oligocarpia quercifolia* Stur, "Culm Flora," Heft ii, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 312, pl. xv, figs. (? 7) 8–12.
1883. *Saccopteris* (*Hymenophyllites*) *quercifolia* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 700 (68).
1885. *Saccopteris* (*Hymenophyllites*) *quercifolia* Stur (*pars*), "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 164 (*non* p. 165, pl. xxxiii, fig. 4).
1899. *Alloiopteris quercifolia* Potonié, "Lehrbuch d. Pflanzenpal.," p. 139, fig. 132.
1913. *Alloiopteris quercifolia* Gothan, "Oberschlesische Steinkohlenflora," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Band lxxv, Teil 1, p. 107, pl. xxiv, fig. 1.
1913. *Zygopteris* (*Corynepteris ?*) *quercifolia* Bertrand, *Ann. Soc. géol. du Nord*, vol. xlii, p. 322.

Remarks.—The only British specimens of this species that I have seen are two small examples which were collected by Mr D. Tait in North Staffordshire. They are preserved on a dark-coloured clayey shale, with which the carbonaceous substance of the pinnules afford too little contrast for reproduction by photography. They are similar in form to that given by Stur in the "Culm Flora" (Heft ii, pl. xv, fig. 8).

Distribution.—Very rare and restricted to the Lower Carboniferous.

CARBONIFEROUS LIMESTONE SERIES OF ENGLAND.

Horizon : In clayey shale, about the centre of the Fifth Grit, in a position probably corresponding to the Upper Limestone Group of the Carboniferous Limestone Series of Scotland (Specimens in the Collection of the Geological Survey, London, Nos. T. 675B, T. 691B).

Locality : Holly Wood, 1 mile north of Endon, small exposure in right bank of stream fully ¼ mile W.N.W. of Endon Mill, North Staffordshire.

Alloiopteris Radstockensis Kidston n. sp.

Plate LXXIII, figs. 1, 1*a*–1*c*.

1888. *Corynepteris erosa* Kidston (*non* Gutbier), " Foss. Flora Somerset and Bristol Coal Field," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 381.
1894. *Corynepteris erosa* Kidston (*non* Gutbier), " Various Divisions of British Carb. Rocks," *Proc. Roy. Phys. Soc. Edin.*, vol. xii, p. 242.
1899. Cf. *Aloiopteris erosa* White (*non* Gutbier), " Foss. Flora Lower Coal Measures of Missouri," *Monogr. U.S. Geol. Surv.*, vol. xxxvii, p. 70, pl. xxiii, fig. 6 ; pl. xxiv, figs. 3A, 3A, *a*.

Description.—Frond of large size, probably tripinnate. Penultimate pinnæ linear-lanceolate, rachis straight, smooth, with a central ridge ; ultimate pinnæ alternate, linear, free, rachis straight, springing from the penultimate rachis at almost right angles and bearing 24 or more pairs of pinnules, which are so much united to each other that the ultimate pinnæ have the appearance of being bordered by a toothed marginal wing. Pinnules alternate, quadrate, united to each other for about half to three-quarters of their length. The pinnules on the lower pinnæ bear one or two prominent teeth which are usually slightly directed forwards ; when only one tooth is present it is placed on the corner of the pinnule which is directed to the apex of the pinna, while the corner facing the base of the pinna has one or two very blunt lobes. On the upper pinnules there is only one forwardly directed tooth and a very slight flattened lobe. The vein entering the pinnule immediately dichotomizes, the foremost arm of the resulting fork extends into the front tooth and the other branch generally divides once or twice, supplying a veinlet to the second tooth when such is present, and the others go to the blunt lobes of the pinnule.

Fructification unknown.

Remarks.—The specimen given natural size on Pl. LXXIII, fig. 1, shows portion of probably a penultimate pinna which is unfortunately imperfect at both base and apex. From the length of the ultimate pinnæ, which are fully 5 cm. long, it is evident that the complete fronds of the species must have attained to a large size.

Some pinnules are shown enlarged three and a half times at figs. 1*a*, 1*b*, and 1*c*. That at 1*a* is from one of the lower pinnæ and shows the two-toothed form of the pinnules and their almost complete union to each other. Of the two veins which arise from a dichotomy at the extreme base of the pinnule, one vein remains simple and enters the front tooth, while the other divides and sends off a veinlet to the other tooth and to the blunt marginal lobes. The pinnules seen at fig. 1*b* are from a pinna holding a higher position on the penultimate pinna. These have only one prominent tooth-like lobe, while fig. 1*c* shows two pinnules from a pinna situated near the upper end of our specimen where each pinnule has only one prominent tooth. The nervation in these uppermost pinnules is limited to the two arms of the basal dichotomy of the vein.

The two nearest European allies to *Alloiopteris Radstockensis* are *Alloiopteris*

(? *Corynepteris*) *cristata* Gutbier sp.* and *Alloiopteris* (? *Corynepteris*) *erosa* Gutbier sp.† From the former of these our species differs in the absence of the regular, sharp-pointed teeth on the upper margin of the pinnules, and from the latter, with which I originally identified the specimen in error, in its possessing a sharp-pointed central tooth with a smaller tooth on each side.

With *Alloiopteris* (? *Corynepteris*) *serrula* Lesqx. sp.,‡ *Pecopteris erosa* Lesqx. (*non* Gutbier),§ and *Alloiopteris* (? *Corynepteris*) *Winslovii* White || our plant has also considerable similarity.¶ From all these, however, *Alloiopteris Radstockensis* is distinguished by its nervation. In the species just mentioned all show that a single vein enters the pinnule and does not dichotomize till it has extended some distance from the base when it gives off veinlets to the teeth, whereas in *Alloiopteris Radstockensis* the vein entering the pinnule dichotomizes at its base, so that the pinnule appears to have two principal veins which may remain simple (fig. 1*c*) or divide to supply veinlets to each tooth or blunt lobe (figs. 1*a*, 1*b*).

With the plant figured by White under the name of *Aloiopteris erosa*,** *Alloiopteris Radstockensis* agrees very closely, if really specifically distinct. White's fig. 6*a*, pl. xxiii, is almost identical with our fig. 1*c*, Pl. LXXIII, and though the enlarged pinnules shown at his fig. 3A*a*, pl. xxiv, have sharper and more clearly defined marginal teeth than those of the British specimen, the nervation seems to be similar.

Distribution.—*Alloiopteris Radstockensis* is very rare, only one specimen of the plant having come under my observation.

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon : ? *Locality :* Braysdown Colliery, near Radstock, Somerset.

Alloiopteris serrula Lesquereux sp.

Plate LXXII, figs. 8, 8*a*, 8*b*.

1858. *Alethopteris serrula* Lesqx. in Rogers, "Geol. of Pennsylvania," vol. ii, part 2, p. 865, pl. xii, fig. 1.
1880. *Pecopteris serrula* Lesqx., "Coal Flora," vol. i, p. 256.
1869. *Pecopteris serrulata* Schimper, "Traité de paléont. végét.," vol. i, p. 525.

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* In Geinitz, "Verstein. d. Steinkf. in Sachsen," p. 29, pl. xxxii, fig. 6, 1855.

† *Alethopteris erosa* Gutbier in Geinitz, *ibid.*, p. 29, pl. xxxii, figs. 7–9.

‡ *Alethopteris serrula* Lesqx. in Rogers, "Geol. of Pennsyl.," vol. ii, pt. 2, p. 865, pl. xii, fig. 1, 1858.

§ "Coal Flora," p. 255, pl. xliv, figs. 1–3, 1879.

|| "Foss. Flora Lower Coal Measures of Missouri," p. 74, pl. xxii, figs. 1–3 ; pl. xxiii, figs. 1–5.

¶ On the relationship of some of these species to each other, see Bertrand, "*Sphenopteris* . . . Nord de la France," *Ann. Soc. géol. du Nord*, vol. xlii, p. 322, 1913.

** White (*non* Gutbier), *op. cit.*, p. 70, pl. xxiii, fig. 6 ; pl. xxiv, fig. 3*a*.

1877. *Oligocarpia* (*Alethopteris*) *serrula* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 294.

1883. *Saccopteris* (*Alethopteris*) *serrula* Stur, "Morph. u. System. d. Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 700 (68).

Description.—Frond large but only fragments of pinnæ known. Penultimate pinnæ; rachis straight, 2 mm. broad. Ultimate pinnæ alternate, narrow-linear, attaining a length of 10 cm. with a breadth of 5 mm., of almost equal width for two-thirds of their length, when they gradually contract into a tapering point, and bear over thirty pairs of pinnules; rachis straight. Pinnules decurrent, alternate, oblique to rachis, united to each other for two-thirds or three-quarters of their length, about 2–5 mm. long and 2 mm. broad, and bearing on their upper margin 2–3 obtuse or blunt-pointed teeth. A single decurrent vein enters the pinnules, and after remaining undivided for a short distance, dichotomizes; the distal arm of this again divides to provide a veinlet to the distal teeth.

Remarks.—The only fragment of this species which is known to have been met with in Britain is given natural size on Pl. LXXII, fig. 8, and enlarged two times at fig. 8*a*. Three pinnules are further enlarged seven and a half times at fig. 8*b* to show more distinctly the dentation and nervation. The pinnules agree so absolutely with the figure and descriptions of the species given by Lesquereux that there can remain no doubt as to the specific identity of our plant. The number of the teeth varies from two to three, but when there are only two, a slight indication of a lobe is present into which a vein extends. This is seen in the central pinnule of the enlargement given at fig. 8*b*. The teeth are obtuse or obtusely pointed. Lesquereux mentions that the teeth are "represented too sharply dentate upon his enlarged fig. 1*a*." *

Alloiopteris serrula is closely related to *Pecopteris angustissima* Sternb.† and *Pecopteris similis* Sternb.,‡ but these both differ in the pinnules being entire. It is, however, more closely related to the *Alloiopteris erosa* Lesqx.,§ and White (*non* Gutbier) || to the *Alloiopteris Winslovii* White ¶ and the *Pecopteris Georgiana* Lesqx.,** but from all these it differs in the blunt-pointed teeth of the pinnules which in the species mentioned above are sharp-pointed. The same character also distinguishes it from *Alethopteris cristata* Gutbier and *Alethopteris erosa* Gutbier.†† The teeth on these two species, in addition to being sharp-pointed, are more regular, and in the first mentioned more numerous.

From *Alloiopteris Radstockensis* it is easily separated by the form of the dentation and the nervation.

* "Coal Flora," p. 257.

† "Essai flore monde prim.," vol. i, fasc. 2, p. 33, pl. xxiii, fig. 1, 1823; fasc. 4, Tent., p. xviii, 1826.

‡ *Ibid.*, vol. i, fasc. iv, Tent., p. xviii; vol. ii, p. 160, pl. xx, fig 1.

§ (*Non* Gutbier) "Coal Flora," p. 255, pl. xliv, figs. 1, 1*a* (? 3), 1879.

|| "Foss. Flora Lower Coal Measures of Missouri," p. 70, pl. xxiii, fig. 6, pl. xxiv, fig. 3*a*, 1899.

¶ *Ibid.*, p. 72, pl. xxii, figs. 1–3; pl. xxiii, figs. 1–5, 1899.

** "Coal Flora," vol. iii, p. 759, pl. xcviii, figs. 6, 6*a*, 1884.

†† In Geinitz, "Verstein. Steinkf. in Sachsen," p. 29, pl. xxxii, figs. 6–9, 1855.

My thanks are due to the kindness of Mr D. DAVIES, F.G.S., for my specimen of *Alloiopteris serrula* Lesqx.

Distribution.—Very rare. The specimen figured here is the only British example of the species known to me.

STAFFORDIAN SERIES.

SOUTH WALES COALFIELD.

Horizon: No. 3 Rhondda Seam. *Locality:* Glamorgan Colliery, Gilfach Goch, Glamorganshire.

Genus **Renaultia** Zeiller.

1883 (August). *Renaultia* Zeiller, *Ann. Sci. Nat.*, 6e sér, Bot., vol. xvi, p. 185, pl. ix, figs. 16–17.
1888. *Renaultia* Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 28, fig. 15.
1885. *Renaultina* Weiss, *Neues Jahrb. für Min.*, Band i, Refer., p. 492.
1883 (December). *Hapalopteris* Stur, " Morph. u. Syst. d. Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 660 (28), fig. 8.
1885. *Hapalopteris* Stur, " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 26, fig. 8.

Description.—Sporangia exannulate, ovoid, free, isolated or arranged in groups of two to five, and situated at the extremities of the veins towards the margin of the pinnules. Foliage sphenopteroid.

Remarks.—The genus *Renaultia* contains a number of small-pinnuled sphenopteroid plants of which the type is *Renaultia chærophylloides* Brongt. sp. The characters of the genus are, however, equally well represented by *Renaultia gracilis* Brongt. sp., of which a fertile specimen is given on Pl. LXXIX, figs. 4, 4*a*–4*g*. The sporangia are of a more or less oval form, and their walls are formed of small cells elongated in the direction of their greater axis.

The limb of the fertile pinnules is generally more or less reduced, and in the case of *Renaultia germanica* Potonié sp. it seems to be almost or entirely suppressed, but in its close ally *Renaultia Hemingwayi*, though reduced, the limb is still present.

The systematic position of the genus is undetermined. The opinion formerly held that *Renaultia* had Marattiaceous affinities must, I think, be given up, as it appears equally, if not more probable, that the members of the genus are Pteridosperms.

Distribution.—The genus *Renaultia* is only known to occur in Upper Carboniferous rocks, and has been recorded from the Staffordian, Westphalian, and Lanarkian Series in Britain.

Renaultia gracilis Brongniart sp.

Plate LXXIX, figs. 1–5.

1828. *Sphenopteris gracilis* Brongt., " Prodrome," p. 51.
1829. *Sphenopteris gracilis* Brongt., " Hist. des végét. foss.," vol. i, p. 197, pl. liv, fig. 2.
1833. *Sphenopteris gracilis* Sternb., " Essai flore monde prim.," vol. i, fasc. v, vi, p. 62.
1870. *Sphenopteris gracilis* Lesqx., " Geol. Survey of Illinois," vol. iv, p. 408 (? pl. xv, figs. 3–6).

1883. *Sphenopteris gracilis* Renault, "Cours de botan. foss.," vol. iii, p. 189, pl. xxxiii, figs. 1–4.
1836. *Cheilanthites gracilis* Göpp., "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 251.
1883. *Renaultia gracilis* Zeiller, *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, p. 185.
1886. *Sphenopteris* (*Renaultia*) *gracilis* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 94, pl. iv, figs. 2, 3.
1893. *Ovopteris gracilis* Potonié, "Flora d. Rothl. v. Thüringen," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft ix, p. 43.
1829. *Sphenopteris fragilis* Brongt., "Hist. des végét. foss.," vol. i, pl. liv, fig. 2 (name on plate).
1879. Cf. *Sphenopteris microcarpa* Lesqx., "Coal Flora," vol. i, p. 280, pl. xlvii, figs. 2, 2*a*, 2*b*.
1907. *Ovopteris rutæfolia* Behrend in Potonié (*pars*), "Abbild. u. Beschreib. foss. Pflanzen" (*K. preuss. geol. Landesanst.*), Lief. v, No. 83, fig. 2 (excl. refs.).
1882. *Sphenopteris microcarpa* Kidston (? *non* Lesquereux) (*pars*), *Ann. and Mag. Nat. Hist.*, ser. 5, vol. x, p. 9, pl. i, figs. 9–14 (*not* figs. 7, 8).
1882. *Sphenopteris microcarpa* Kidston (? *non* Lesquereux) (*pars*), *Proc. Roy. Phys. Soc. Edinburgh*, vol. vii, p. 129, pl. i, figs. 9–14 (*not* figs. 7, 8).
1883. *Renaultia microcarpa* Zeiller (? *non* Lesquereux), *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, p. 186.
1888. *Renaultia microcarpa* Zeiller (? *non* Lesquereux), "Flore foss. bassin houil. de Valenciennes," p. 29, fig. 15.
1891. *Renaultia microcarpa* Kidston (? *non* Lesquereux), "On the Fructification, etc., of Carboniferous Ferns," *Trans. Geol. Soc. Glasgow*, vol. ix, p. 26, pl. ii, fig. 25.
1899. *Renaultia microcarpa* Potonié (? *non* Lesquereux), "Lehrb. d. Pflanzenpal.," p. 92, fig. 26, A, B.
1900. *Renaultia microcarpa* Zeiller (? *non* Lesquereux), "Éléments de paléobot.," p. 57, fig. 22, A, B.
1901. *Renaultia microcarpa* Kidston (? *non* Lesquereux), "Flora of Carboniferous Period," *Proc. Yorks. Geol. and Polytech. Soc.*, vol. xiv, pt. 2, p. 193, pl. xxviii, fig. 4.

Description.—Frond quadripinnate. Primary pinnæ forming a wide angle at union with rachis, somewhat distant, narrow, triangular, usually not touching each other laterally, though their margins sometimes meet; rachis 1–2 mm. broad, straight or more or less flexuous, smooth, not winged. Secondary pinnæ alternate, somewhat distant, not touching, oval-lanceolate, rachis straight or flexuous, winged. Tertiary pinnæ free, oblong-lanceolate, distinctly winged, rachis straight or slightly flexuous. Pinnules alternate, free, attached by a wide footstalk, spreading outwards or slightly directed forwards, ovate, decurrent, and varying much in size according to their position on the rachis; the lower pinnules are divided into 3–4 pairs of alternate lobes, which are separated by a sinus extending inwards about half-way to the mid-rib; lobes directed forwards, the basal bearing 2–3 blunt-pointed crenatures, or frequently with a shallow sinus at their apex, the upper lobes entire or slightly emarginate, terminal lobe bifid, emarginate, or rounded; upper pinnules with 1–3 blunt lobes, rounded or emarginate, almost entire. Limb of pinnule formed of very delicate tissue. Nervation prominent, the central slightly flexuous vein gives off simple or dichotomously divided lateral veinlets, one of which enters each tooth or lobe, and terminates at the margin of the pinnule. Fertile pinnæ with limb of pinnules slightly reduced. Sporangia marginal, small, oval, from 0·35–0·40 mm. long, and 0·25–0·30 mm. broad, exannulate, single or placed in groups of 2–3 at the ends of the veinlets. Wall of sporangium composed of cells elongated in the direction of the greater axis. Spores numerous, sub-triangular, with rounded angles and triradiate ridge, smooth, 33 μ in diameter.

Remarks.—Although *Renaultia gracilis* Brongt. does not seem to be very uncommon in Britain, specimens showing their minute segmentation distinctly are not very frequently obtained, on account of the delicate nature of the limb of the pinnules.

The specimens given at figs. 1–5, Pl. LXXIX, illustrate the general character of the pinnule variation. The example seen at fig. 5 shows the characteristic distant secondary and tertiary pinnæ and the small free pinnules. On the small example given at fig. 2, the secondary pinnæ are somewhat closer. The segmentation of the pinnules varies considerably in the extent to which the lobes are separated from each other. On the basal pinnæ the lobes of the pinnules are separated by a sinus which extends to within a short distance from the midrib, and, as seen in fig. 5, the segments become completely separated, except for the decurrent band which forms the wing to the rachis. In such cases the ultimate divisions assume the form of small pinnules, and may be regarded as such.

The small examples given at figs. 2 and 3 probably held a higher position on a frond or pinna, and show corresponding variation in the depth of the sinus between the lobes. These two specimens may represent the tripinnately divided portion of the frond, while that at fig. 5 the lower and quadripinnate condition.

The fertile specimen shown natural size on Pl. LXXIX, fig. 4, enlarged two times at fig. 4*a* and a part enlarged eleven times at fig. 4*b* to show the arrangement of the sporangia, I originally identified as *Sphenopteris microcarpa* Lesqx. Our specimen is, however, certainly referable to *Sphenopteris gracilis* Brongt., as seen by the sterile portion lying beside the fertile pinnæ on fig. 4*a*. On the other hand, it is extremely difficult to find any definite character by which LESQUEREUX's plant can be separated from BRONGNIART's species, and it appears almost certain that they are specifically identical, though I provisionally include the reference to LESQUEREUX's specimen in the synonymy with a sign of doubt.

A portion of the Blairpoint specimen is enlarged eleven times at fig. 4*b* to show the arrangement of the sporangia ; the limb of the fertile pinnules is slightly reduced, but this is seen better at fig. 4*a*, which is enlarged two times. The free sporangia are placed singly at the extremities of the veins (fig. 4*d*) or in little groups of two or three. At fig. 4*e* a group of three sporangia is seen enlarged twenty-five times to show the cells of the sporangium wall. The sporangia vary slightly in form, some being more broadly oval than others (figs. 4*e* and 4*f*).

To obtain the spores a maceration preparation was made, and the contents of a sporangium (enlarged one hundred and five times) are seen at fig. 4*g*. The spores had not reached maturity, and are firmly united to each other, probably by mineral matter. One, however, projecting from the margin of the spore-mass, is enlarged five hundred times at fig. 4*h*. It is triangular, with rounded angles, and bears a triradiate ridge on its smooth surface.

Renaultia gracilis forms one of a group of closely allied species which give much difficulty in their specific identification. The limb of the pinnules of all the members of this group is of very delicate texture and is comparatively seldom found in a good state of preservation. The veins, on the other hand, are very strong, and occasionally one meets with specimens on which the limb has entirely disappeared and the veins alone remain.

The chief distinctive characters of *Renaultia gracilis* are its more or less distant pinnæ, which are broadly lanceolate and seldom touch each other laterally as they do in most of its near allies, where also the pinnæ are usually much more distinctly triangular. These characters give the plant a laxer type of growth than that of *Sphenopteris Footneri* Marrat, which is perhaps its nearest ally.

In the latter, the ultimate pinnæ, as well as the pinnules, are more broadly triangular and the plant has a more dense or solid appearance. These differences, difficult to convey in words, will be easily seen if the specimens of *Renaultia gracilis* given on Pl. LXXIX, figs. 1, 2, 3, and 5 be compared with those of *Sphenopteris Footneri* on Pl. XXIV, figs. 1, 2. There is also in the latter species a constant overlapping or touching of the pinnæ of various degrees at their margins.

At one time I united these two species, but now believe them to be specifically distinct.

Under the name of *Ovopteris rutæfolia*, Behrend seems to have included more than one species. That given at fig. 2 is quite indistinguishable from *Renaultia gracilis*, and is united with it here.

The fertile specimen figured and described by Potonié under the name of *Renaultia* (*Sphenopteris*) *microcarpa*,* in the form and size of its pinnules, agrees with neither *Sphenopteris microcarpa* Lesqx. nor *Renaultia gracilis*, nor do I think it can be referred to either of them. It accords much better with fertile specimens of *Boweria Schatzlarensis*.† The sporangia had all been removed from Potonié's specimen and their position was only indicated by small depressions. In the absence of any knowledge of the structure of the sporangia it is, however, impossible to determine the generic position of the specimen.

The type of *Renaultia gracilis* Brongt. sp. came from the "Mines of Newcastle-on-Tyne."

Distribution.—Owing to my having at one time regarded *Sphenopteris Footneri* to be a form of *Renaultia gracilis* and not separated them in my records, I am unable to give a full distribution of the species, as a number of the specimens on which my records were founded cannot now be traced. It occurs, however, in both the Westphalian Series and the Lanarkian Series.

WESTPHALIAN SERIES.

Burnley Coalfield.

Horizon: Arley Mine. *Locality:* Brickwork, Hibson Road at Marsden Height, Nelson, Lancashire (P. Whalley).

* *Jahrb. k. preuss. geol. Landesanst. für 1889*, p. 25, pl. v, figs. 3*a*, 3*b*, 1890.

† *Cf.* pl. lxxi, fig. 3.

Forest of Wyre Coalfield.

Horizon: Brooch Coal. *Locality:* Kinlet Colliery, 1 mile south-west of Highley, Shropshire (Collection of Geological Survey of England, London).

Northumberland and Durham Coalfield.

Horizon: Crow Coal. *Locality:* Phœnix Brickworks, Crawcrook, Ryton, County of Durham (W. Eltringham).

Horizon: Stone Coal. *Locality:* Stargate, Ryton (W. Eltringham).

Horizon: ? *Locality:* "Mines of Newcastle-on-Tyne" (Brongniart, type).

South Staffordshire Coalfield.

Horizon: Roof of Fireclay Coal. *Locality:* Doulton's Clay Pit, Netherton (H. W. Hughes).

Horizon: Between Fireclay Coal and Bottom Coal. *Locality:* Netherton (H. W. Hughes).

Warwickshire Coalfield.

Horizon: Ryder Coal. *Locality:* Kingsbury Colliery, 5½ miles south of Tamworth (R. D. Vernon).

Horizon: Thick Coal. *Localities:* Exhall Colliery, 3¾ miles N.N.E. of Coventry (R. D. Vernon); Newdigate Colliery, 4 miles S.W. of Nuneaton (R. D. Vernon).

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Localities:* Monckton Main Colliery, near Barnsley (W. Hemingway); Acton Hall Colliery, near Pontefract (W. Hemingway).

LANARKIAN SERIES.

Fifeshire Coalfield.

Horizon: Near base of coal-bearing strata. *Locality:* Shore, Blairpoint, Dysart.

Lanarkshire Coalfield.

Horizon: Kiltongue Coal. *Locality:* Mount Vernon.

Stirlingshire Coalfield.

Horizon: Ball Coal. *Localities:* Meadowbank Pit, ½ mile south of Polmont (Collection of Geological Survey of Scotland, Edinburgh); No. 13 Callendar Pit, ¼ mile S.S.E. of the Glen, 1⅓ mile south of Falkirk (Collection of Geological Survey of Scotland, Edinburgh).

Renaultia chærophylloides Brongniart sp.

Plate LXXVIII, figs. 3, 3*a*, 3*b*, 4, 4*a*.

1835. *Pecopteris chærophylloides* Brongniart, "Hist. des végét. foss.," p. 357, pl. cxxv, figs. 1, 2.
1883. *Pecopteris chærophylloides* Renault, "Cours de botan. foss.," vol. iii, p. 124, pl. xxi, figs. 10, 11.
1838. *Sphenopteris chærophylloides* Presl in Sternberg, "Versuch," ii, fasc. vii-viii, p. 131.
1883. *Renaultia chærophylloides* Zeiller, *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, pp. 185, 208, pl. ix, figs. 16, 17.
1886. *Sphenopteris* (*Renaultia*) *chærophylloides* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 90, pl. xi, figs. 1, 2.
1910. *Sphenopteris* (*Renaultia*) *chærophylloides* Renier, "Documents pour l'étude paléont.," pl. lxii.
1883. *Hapalopteris typica* Stur, "Morph. u. Syst. d. Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 660 (28), fig. 8.
1885. *Hapalopteris typica* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 46, text-fig. 8, p. 27; pl. xlii, figs. 3, 4.

Description.—Frond tripinnate (?), rachis smooth, straight or slightly flexuous. Primary pinnæ alternate, spreading, distant or touching at their margins, rachis straight or slightly flexuous, smooth or punctate. Secondary pinnæ alternate, lanceolate, spreading, those at the base of the primary pinnæ a little shorter than those placed immediately above them, touching at their margins or slightly overlapping, rachis subflexuous, winged; the larger pinnæ bear from 6–8 pinnules. Pinnules alternate, decurrent, attached by a very broad footstalk, ovate, and bearing 3–6 obtusely pointed subtriangular lobes which are separated by a shallow sinus; the lobes may further bear a few obtusely pointed teeth. The surface of the pinnules sometimes show traces of very small, short, adpressed hairs. The almost straight central vein gives off simple or dichotomously divided lateral veinlets, one of which enters each tooth or lobe.

Fertile pinnules slightly reduced, with less prominent lobes; sporangia free, ovoid, exannulate, 0·35 mm. long and from 0·18 mm. to 0·20 mm. broad, single or placed in groups of 3–5 at the extremities of the veins.

Remarks.—Part of a frond of *Renaultia chærophylloides* Brongt. sp., in the collection of the Sedgwick Museum, Cambridge, is given natural size at fig. 1, and a small portion of it is enlarged two times at fig. 1*a*. This specimen shows the characteristic roughening of the surface of the pinnules, though the small hairs themselves are scarcely observable. The carbonaceous matter forming the fossil has somewhat broken away from the margins of the pinnules, so that their outline is not clearly defined.

Another specimen is given at fig. 3 which shows part of a penultimate pinna. The rachis of the penultimate pinna is slightly flexuous, while those of the ultimate pinnæ are straight. A few pinnæ from this example are enlarged two times at fig. 3*a* to show the form and segmentation of the pinnules. The lobes vary in the depth of their separation from each other according to their position on the rachis. The enlarged pinnule seen at fig. 3*b* is from an upper pinna, but on some of the other pinnules the sinus separating the segments extends more deeply into the pinnule. The nervation is not well seen on any of our specimens, but it consists of a central vein which gives off a lateral veinlet to each tooth or lobe.

The small, oval, exannulate sporangia are placed singly or in small groups at the ends of the veinlets. No fertile examples have, however, been met with in Britain.

Among the species known to occur in the Carboniferous rocks of Britain, the only three with which *Renaultia chærophylloides* is likely to be mistaken are *Renaultia stipulata* Gutbier sp., *Renaultia gracilis* Brongt. sp., and *Sphenopteris Footneri* Marrat. The first is easily distinguished by the obtuse lobes of the pinnules, and the two others by their much more delicate texture, as well as by the form of the pinnule-segments, which are more obtuse and generally truncate or emarginate. When the condition of preservation permits the small adpressed hairs on the surface of the pinnules of *Renaultia chærophylloides* being observed, this at once separates it from the three species just mentioned.

Stur states that the principal rachis of *Renaultia chærophylloides* Brongt. sp. (= *Hapalopteris typica* Stur), bore aphlebiæ at the base of the primary pinna, but these have not been observed on our specimens, which are probably too fragmentary to show them.

One of Brongniart's types came from the neighbourhood of Manchester.

My thanks are due to the Curator of the Sedgwick Museum, Cambridge, for permission to figure the specimen shown on Pl. LXXVIII, fig. 4.

Distribution.—Though recorded from several localities, *Renaultia chærophylloides* is a rare British species, some of the records being founded on a single occurrence.

STAFFORDIAN SERIES.

Somerset and Bristol Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: ? *Locality:* Broad Oak Colliery, Pensford, Somersetshire (R. Crookall).

Kent Coalfield.

Horizon: At depth of 1768 feet and 1980 feet. ? Etruria Marl Group. *Locality:* Boring at Tower Brickworks, Folkestone (Collection of Geological Survey, London).

South Wales Coalfield.

Horizon: No. 3 Rhondda Seam. Blackband Group. *Locality:* Glamorgan Colliery, Gilfach Goch, Glamorganshire (D. Davies).

WESTPHALIAN SERIES.

North Derbyshire and Nottingham Coalfield.

Horizon: Top Hard Coal. *Locality:* Digby Clay Pit, Kimberley (Dr L. Moysey).

Lancashire Coalfield.

Locality: " Neighbourhood of Manchester " (Brongniart).

WARWICKSHIRE COALFIELD.

Horizon: Seven-foot Seam. *Locality:* Chilvers Coton Clay Pit, Heath End, Nuneaton (R. D. VERNON).

YORKSHIRE COALFIELD.

Horizon: Roof of Old Hards Coal. *Locality:* Hartley Bank Pit, Horbury.

Renaultia rotundifolia Andrae sp.

Plate LXXX, figs. 1–6.

1869. *Sphenopteris rotundifolia* Andrae, "Vorwelt. Pflanzen," p. 37, pl. xii, figs. 1, 2.
1920. *Sphenopteris rotundifolia* Dubois, *Ann. Soc. géol. Belgique*, vol. xliii, livr. 1, p. B. 77.
1883. *Hapalopteris rotundifolia* Stur, "Morph. u. Syst. der Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 664 (32).
1885. *Hapalopteris rotundifolia* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 31, pl. xli, fig. 9; pl. xliv, figs. 1–4.
1899. *Renaultia rotundifolia* Zeiller, "Étude sur la Flore foss. du bassin houil. d'Héraclée (Asie Mineure)," *Mém. Soc. géol. France, Paléont.*, xxi, p. 17.
1862. *Sphenopteris marginata* Dawson, "Flora of Devonian Period in North-Eastern America," *Quart. Journ. Geol. Soc.*, vol. xviii, p. 321, pl. xv, figs. 38*a*, 38*b*.
1868. *Sphenopteris marginata* Dawson, "Acadian Geology," p. 551, fig. 192 D.
1871. *Sphenopteris marginata* Dawson, "Foss. Plants Devon. and Upper Silur. Form." (*Geol. Survey Canada*), p. 52, pl. xvi, fig. 184.
1888. *Sphenopteris marginata* Dawson, "Geol. Hist. Plants," p. 73, fig. 23 D.
1910. *Sphenopteris marginata* Matthew, "Oldest Silur. Flora," *Bull. Nat. Hist. Soc. New Brunswick*, vol. vi, No. xxviii, p. 248.
1914. *Sphenopteris marginata* Stopes, "Fern Ledges, Carboniferous Flora," *Canada, Dept. of Mines, Geol. Survey Mem.*, No. 41, p. 32, pl. viii, figs. 18–20, text-fig. 1, p. 33.
1916. *Sphenopteris* (*Renaultia*) *Schwerini* Arber (*non* Stur sp.), "Fossil Floras of Coal Measures of South Staffordshire," *Phil. Trans. Roy. Soc. Lond.*, ser. B, vol. ccviii, p. 142, pl. ii, figs. 1 and 5, text-fig. 1.

Description.—Frond quadripinnate, primary rachis somewhat slender, longitudinally striated, smooth on upper portion, but apiculate on lower region. Primary pinnæ alternate, broadly lanceolate or subtriangular, rachis smooth, slightly flexuous. Secondary pinnæ broadly lanceolate, rachis slender, smooth, straight or flexuous. Tertiary pinnæ lanceolate or oblong-lanceolate, rachis generally straight, but sometimes flexuous.

Pinnules alternate, free or touching each other laterally, those on middle pinnæ oblong-lanceolate, contracted at base into a narrow foot-stalk and bearing two to three pairs of rounded or blunt-pointed entire lateral lobes with a terminal lobe of the same form, on uppermost pinnæ the pinnules are trilobate and finally become reduced to a simple sessile, ovate, decurrent lobe. On the lowest pinnæ the lobes of some of the pinnules become separate and assume the form of trilobate or simple oval pinnules. At the apex of the pinnæ, a few of the pinnules are more or less united to each other. Nervation: each pinnule has a slightly flexuous midrib which gives off simple or dichotomous branchlets to each lobe. Fructification: sporangia exannulate, 0·5 mm. in length, very numerous, placed at the margin of the lobes of the pinnule and apparently forming little groups, or irregular in position and covering almost the whole of the fertile lobe.

Remarks.—Renaultia rotundifolia varies much in the size of the pinnules and several specimens illustrating this are seen at figs. 1–4, Pl. LXXX. The extent of flexuosity of the rachis also varies considerably. The pinnules on all these specimens are identical in form and segmentation. The specimens seen at figs. 1–2 are enlarged two times at figs. 1*a*, 2*a*. That enlarged at fig. 2*a* is similar in form of pinnule and segmentation to the example given, natural size, at fig. 4. These various specimens may represent portions from different levels of the frond or some of them may be fragments of young individuals of the species. The specimens given at figs. 1–3 are all from the same locality. My thanks are due for this series of specimens to the Rev. H. KAY. The largest form of the species which I have seen is that given at fig. 4, natural size, which is in the collection of the Geological Department of the British Museum, and for the privilege of figuring it here I am indebted to the kindness of Dr A. SMITH WOODWARD. The lobes of the pinnules are rounded, rarely bluntly pointed, as seen at figs. 6*a* and 6*b*, and, so far as my observations go, always entire. The nervation is seldom well seen, but was shown on the specimen, of which a fragment appears on Pl. LXXX, fig. 1, and from which the figs. 6*a* and 6*b* were taken.

The sporangia have been described by STUR. All the British examples met with have been sterile.

BERTRAND * regards *Renaultia rotundifolia* as a form of *Sphenoteris Laurenti* Andrae, and BEHREND unites both these species with *Ovopteris rutæfolia.*† This latter writer has, however, most certainly included more than one species under his *Ovopteris rutæfolia*. On the other hand GOTHAN regards these two plants as specifically distinct,‡ an opinion with which I am in complete accord.

Renaultia rotundifolia and *Renaultia Laurenti* appear to me to be essentially distinct. The penultimate and ultimate pinnæ of *Renaultia rotundifolia* are much more deltoid or deltoid-lanceolate than those of *Sphenopteris Laurenti*, where they are much more lanceolate or even linear. If the figures of *Sphenopteris Laurenti* given on Plates IX, figs. 1, 2, and X, figs. 1–3, be compared with those of *Renaultia rotundifolia* seen on Pl. LXXX, these differences can be distinctly observed.

The linear ultimate pinnæ and the prominent spines on the rachis easily separate *Sphenopteris spinulosa* Stur sp. from *Sphenopteris rotundifolia* Andrae.

From the refiguring by Dr STOPES of the specimen of *Sphenopteris marginata* given by DAWSON in 1871 in his "Fossil Plants of the Devonian and Upper Silurian Formations," § pl. xvi, fig. 184, it is perfectly clear that the *Renaultia rotundifolia* Andrae sp. is identical with DAWSON's *Sphenopteris marginata*. The first figure and description of this species were published by DAWSON in 1862 (*loc. cit.*) and the same

* "Liste provisoire des *Sphenopteris*," *Ann. Soc. géol. du Nord*, vol. xlii, p. 325, 1913.

† Behrend in POTONIÉ, "Abbild. u. Beschreib. foss. Pflanzen," *K. preuss. geol. Landesanst.*, No. 83, 1907.

‡ "Oberschlesische Steinkohlenflora," Teil 1, pp. 134, 135, 1913.

§ The flora of the "Fern Ledges" is now known to be of Westphalian Age; not Devonian as originally supposed by DAWSON.

description and illustrations were again reproduced by him in 1868 (*loc. cit.*), but they are so imperfect a representation of the plant that it is most improbable that his species could be identified from them by subsequent workers. It was not, however, until 1869 that ANDRAE described and gave excellent figures of his *Sphenopteris (Renaultia) rotundifolia*, and, by the law of priority, DAWSON's specific name of "*marginata*" should supersede that of "*rotundifolia*." As, however, neither DAWSON's original description nor figures supply sufficient data for a satisfactory re-identification of his plant, I retain the specific name of "*rotundifolia*," as it seems unreasonable to refer one to an inadequate description and figures of a species.

Distribution.—Sphenopteris rotundifolia is not a common British species. It has, however, been recorded from both the Staffordian Series and the Westphalian Series.

STAFFORDIAN SERIES.

SOUTH STAFFORDSHIRE COALFIELD.

ETRURIA MARL GROUP.

Horizon: In upper 300 feet of Old Hill Marls. *Locality:* Granville Pit at Old Hill Station (Rev. H. KAY).

WESTPHALIAN SERIES.

BURNLEY COALFIELD.

Horizon: Above Arley Mine. *Locality:* Brickwork, Hibson Road at Marsden Height, Nelson, Lancashire (P. WHALLEY).

NORTH DERBYSHIRE AND NOTTINGHAM COALFIELD.

Horizon: ? *Locality:* Clay Cross (Dr L. PEGLER).

NORTHUMBERLAND AND DURHAM COALFIELD.

Horizon: Five-quarter Seam. *Locality:* West Thorley Colliery, Tow Law, County of Durham (J. T. STOBBS).

TITTERSTONE CLEE HILL COALFIELD.

Horizon: 164 feet 2 inches above Gutter Coal. *Locality:* Chimney Pit Bore, Clee Hill, near Ludlow, Shropshire (R. L. ROBERTS).

WARWICKSHIRE COALFIELD.

Horizon: Seven-foot Seam. *Locality:* Chilvers Coton Clay Pit, Heath End, Nuneaton (R. D. VERNON).

YORKSHIRE COALFIELD.

Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley (W. HEMINGWAY).

Renaultia Crepini Stur sp.

Plate LXXX, figs. 7, 7*a*.

1885. *Hapalopteris Crepini* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 54, pl. xli, figs. 5, 6.
1899. *Sphenopteris* (*Renaultia*) *Crepini* Zeiller, "Flore foss. bassin houil. d'Héraclée" (*Mém. Soc. géol. France, Paléont.*, xxi), p. 15, pl. i, fig. 10.
1912. *Sphenopteris Crepini* Vernon, "Geology and Palæontology of Warwickshire Coalfield," *Quart. Journ. Geol. Soc.*, vol. lxviii, pp. 620, 637, pl. lviii, fig. 2.

Description.—Frond at least quadripinnate. Penultimate pinnæ lanceolate, alternate, rachis subflexuous, punctate; ultimate pinnæ lanceolate, distant; rachis subflexuous, winged. Pinnules small, alternate, ovate-lanceolate, attached by a broad base, the lower having three pairs of prominent segments which again bear two or three short blunt lobes; the upper pinnules have fewer primary segments with a smaller number of secondary lobes, or the segments may be entire. The flexuous midvein gives off a veinlet to each primary segment where it divides to supply a branch to each lobe.

Sporangia oval, exannulate, outer surface showing a cellular reticulation 0·30 mm. to 0·40 mm. long, placed singly or forming small groups at the margins of the pinnules and probably situated on the extremities of the veinlets.

Remarks.—Of *Renaultia Crepini* Stur sp. I have only seen a few small specimens. Though the example from Dodworth, given at fig. 7, Pl. LXXX, is very small, it shows quite clearly the form and segmentation of the pinnules. This example is probably from a lower portion of the frond than other two specimens collected by Mr Hemingway at the same locality, as the pinnules on the figured example are slightly larger and the primary segments have a greater number of lobes which are also more prominent. A pinnule from the specimen given at fig. 7 is enlarged six times at fig. 7*a*. It has three pairs of lateral segments which are separated by a sharp-pointed sinus for about a distance of one-third the width of the pinnule. Of the three lateral segments the lowest and uppermost pair are about the same size and smaller than the pair placed between them. The lower segments have each three small obtuse lobes with a tendency to end in a blunt point. Sometimes the terminal lobes of these segments are emarginate, but more generally they are blunt-pointed. The terminal segment is very similar in form to one of the upper lateral segments. The pinnules are attached to the rachis by a broad base which nearly equals the whole width of the solid central part of the pinnule into which the sinus dividing the segments does not extend. The pinnules at the base of the pinnæ are frequently smaller than those immediately above them.

On another specimen from Dodworth,* also collected by Mr Hemingway, there occur a number of fragments of *Renaultia Crepini*. Among these is a portion of a

* Kidston Collection, No. 3278.

densely apiculate rachis 5 mm. broad, which indicates that the fronds must have attained to a considerable size. Another fragment of a tripinnate apiculate rachis, about 7 cm. long and 1 mm. broad, which occurs on the same small slab, shows a distinct dichotomy a short distance below its upper end where broken over, and beneath this point (perhaps caused through an excessive geniculation of the rachis) two other dichotomous-like forks are seen. The pinnules attached to various pieces of rachis show that the specimen is a fragment of *Renaultia Crepini*, but the pinnules are slightly smaller on this example than those seen on fig. 7, and their lobes in some cases are entire, but others bear small teeth as seen at fig. 7*a*. The rachises of the smaller pinnæ appear to have been smooth.

The fructification has been described by Stur.

The somewhat distant pinnæ, and the elongated form and the segmentation of the pinnules, afford good characters for the identification of *Renaultia Crepini* Stur sp.

Distribution.—*Renaultia Crepini* is very rare and has only been met with sparingly at two localities in the Westphalian Series.

WESTPHALIAN SERIES.

Warwickshire Coalfield.

Horizon : Seven-foot Seam. *Locality :* Chilvers Coton Clay Pit, Heath End, Nuneaton (R. D. Vernon).

Yorkshire Coalfield.

Horizon : Parkgate Coal. *Locality :* Dodworth, near Barnsley (W. Hemingway).

Cf. **Renaultia** sp.

Plate LXXXI, figs. 2, 2*a*, 3, 3*a*, 4.

1886. *Sphenopteris* (*Hapalopteris*) *Schützei* Kidston (*non* Stur), "Fossil Plants Lanarkshire Coalfield," *Trans. Geol. Soc. Glasgow*, vol. viii, p. 57, pl. iii, figs. 5, 5*a*, 5*b*.

Remarks.—I place provisionally under Cf. *Renaultia* sp. some small specimens of a *Sphenopteris*, received in 1886 from the late R. Dunlop, which were originally referred in error to *Hapalopteris Schützei* Stur. The specimens consist of some fragments of fertile and sterile pinna.

Figs. 2 and 3 show two of the fertile portions of pinnæ natural size, which are enlarged two times at figs. 2*a* and 3*a*. The ultimate pinnæ are alternate, lanceolate, and distant. The pinnules are lanceolate, and the lower are divided into 6–7 narrow segments which have one or two short teeth. At the extremity of each of those a sporangium is placed. Some reduction seems to have taken place in the length of the teeth, for the sporangia often appear as if two or three formed a row at the extremity of the lobe, though each in reality has occupied an individual tooth. The sporangia themselves have in almost all cases fallen off, and their former presence is indicated by a small oval depression. On the upper right-hand corner of fig. 3 a few sporangia are seen in position, but the carbonaceous matter which formed their walls has been removed and only a cast of their interior left. It is therefore impossible to determine whether the sporangia were annulate or exannulate, and consequently their systematic position remains undecided.

One of the specimens * shows some sterile pinnules in organic connection with some fertile ones. They are similar to that shown enlarged two times at fig. 4, but the small fragment figured shows more clearly their form. The larger pinnules are divided into five or six linear lobes which end in a sharp point, through the rounding of the distal apical angle; and into each of these a single vein enters.

I am now satisfied that these specimens are not referable to *Hapalopteris Schützei* Stur, but do not know of any other species with which they agree. Until more perfect examples are obtained I have, therefore, deemed it better to treat the plant provisionally as cf. *Renaultia* sp.

LANARKIAN SERIES.

Lanarkshire Coalfield.

Horizon: Kiltongue Coal. *Locality:* Debris from the foundation of the Caledonian Railway Bridge at Calderbank, about 2 miles south of Airdrie (R. Dunlop).

Renaultia Hemingwayi Kidston n. sp.

Plate LXXXII, figs. 1, 1*a*–1*c*, 2, 2*a*–2*c*.

1904. *Sphenopteris* cf. *Aschenborni* Hemingway (*non* Stur) in Gerrard, "Fossils found at Bradford Colliery, Manchester," *Trans. Manchester Geol. and Mining Soc.*, vol. xxviii, pt. xix, p. 561, pl. iii, fig. 2.

Description.—Frond quadripinnate. Rachis 2·50 mm. or more broad, densely punctate, with very small apiculi. Primary pinnæ alternate, lanceolate, with an aphlebia at their base, rachis 1·75 mm. thick at base, finely punctate and very slightly flexuous. Aphlebia with central flattened axis which gives off free, lateral, pinnate segments with sharp-pointed teeth. Secondary pinnæ linear-lanceolate, alternate, their margins touching, rachis slightly flexuous, rather less than 0·50 mm. broad, spreading outwards and slightly directed forwards; lower secondary pinnæ bear fifteen or more pairs of tertiary pinnæ. Tertiary pinnæ alternate, ovate-lanceolate, usually contracted suddenly into a bluntish point, rachis straight, winged; basal tertiary pinnæ bear 5–6 pairs of pinnules; the upper pinnæ gradually become pinnatifid, whilst those at the apex of the secondary pinnæ are reduced to small quadrifid structures and assume the form of pinnules. Pinnules alternate, closely placed, very

* Kidston Collection, No. 173.

small, from 1 mm. to 2 mm. long according to position on pinna, decurrent, oval, the lower ones divided into four to six roundish-truncate or blunt-pointed lobes which are separated by a sharp-pointed sinus that extends inwards about half way to the midrib ; terminal lobe of pinnule rounded or emarginate ; uppermost pinnules with very few lobes and a bifid or trifid terminal pinnule with rounded or truncate points. Nervation seldom distinctly seen, but consisting of a central vein which sends off a lateral veinlet into each lobe or tooth. Fructification borne on the tertiary pinnæ of the upper part of the primary pinnæ. Sporangia placed in small groups at the ends of the ultimate divisions of the pinnules, small, exannulate, broadly oval or sub-orbicular, 0·25 mm. in greater diameter. Wall composed of small cells slightly longer than broad. The limb of the fertile pinnules is more or less reduced.

Remarks.—This species is very similar in habit to *Renaultia germanica.* They both have possessed fronds of considerable size and bore their sporangia on the upper portions of the primary pinnæ. The general character of growth of *Sphenopteris Sewardi*, and the position of the sporangia, seem also to have been of a similar type, but the structure of its sporangia is not known.

On Pl. LXXXII, fig. 1, a specimen of *Renaultia Hemingwayi* is given natural size. It shows fragments of two primary pinnæ. That at the base of the figure is sterile, but a fertile fragment is seen at the upper margin. The sporangia, however, are not sufficiently well preserved to show their structure.

The larger ultimate pinnæ are about 9 mm. long, lanceolate or oblong-lanceolate, and contracted at the apex into a rather blunt point. The pinnules seldom exceed 2 mm. in length and the basal ones have two, seldom three pairs of almost opposite segments with blunt, or sometimes subtruncate apices. The enlargements given at figs. 1*a* and 1*b* show the form of the ultimate pinnæ and pinnules.

An incomplete aphlebia is seen to spring from the main rachis at the point indicated by the arrow on fig. 1, where a primary pinna is given off. It has a flat central portion from which arise alternate pinnate segments whose teeth end in sharp points. It is enlarged three times at fig. 1*c*.

A larger specimen is given at fig. 2, natural size. This example is preserved in the Museum of the University of Manchester, and I am indebted to the kindness of the Curator for permission to figure and describe it. It shows several fragments of primary pinnæ, those at the upper margin of the figure being fertile. On these fertile secondary pinnæ some of the basal tertiary pinnæ are sterile and bear the ordinary foliage pinnules. On the fertile pinnæ the limb of the pinnule is reduced, and the small sporangia seem to have been arranged in little groups at the extremities of their ultimate divisions. The sporangia are very small, broadly oval or almost circular, and measure about 0·25 mm. in diameter. They are exannulate, and their walls are formed of small cells slightly longer than broad. A few sporangia are enlarged twenty-seven times at fig. 2*b*.

Some sporangia were macerated and their spore contents obtained, but the spores were in an early state of development and their individual form was not well defined.

The contents of such a sporangium are seen at fig. 2*c*, enlarged two hundred and fifty times.

The fertile pinnæ of *Renaultia Hemingwayi* are very similar to those of *Renaultia germanica* Potonié, but in the latter species the secondary and tertiary pinnæ are deltoid. They are also more lax, and their component parts more distant from each other. If the figures of the corresponding parts of these two species be compared, these differences can be distinctly observed.* As the sterile condition of *Renaultia germanica* is unknown no comparison can be made with the foliar organs.

The specimen given on Pl. LXXXII, fig. 1, was originally figured in Mr GERRARD's paper (*loc. cit.*) as *Sphenopteris* cf. *Aschenborni* Stur. This species is now united with *Sphenopteris Schatzlarensis* Stur sp., in which the ultimate pinnæ are shorter and broader in proportion to their length, the pinnule segments are more deeply cut in, more spreading, and have sharper points.†

I have much pleasure in naming this *Renaultia* after Mr W. HEMINGWAY, from whom I have received so much kind assistance in my study of the British Carboniferous flora, and from whom the specimen given at fig. 1, Pl. LXXXII, was received.

Distribution.—Very rare. The specimen given on Pl. LXXXII, fig. 1, occurred in the Staffordian Series; that shown at fig. 2 is in the "Dawes Collection," Museum, University, Manchester, but the locality and horizon are unknown.

STAFFORDIAN SERIES.

LANCASHIRE COALFIELD.

BLACKBAND GROUP.

Horizon: From between 24 to 321 feet above Bradford Four-foot Coal. *Locality:* Bradford Colliery, Manchester (W. HEMINGWAY).

Renaultia germanica Potonié sp.

Plate LXXXI, figs. 1, 1*a*.

1890. *Hymenophyllites* (*Sphenopteris*) *germanica* Potonié, "Ueber einige Carbonfarne, I," *Jahrb. k. preuss. geol. Landesanstalt für* 1889, p. 23, pl. iv, figs. 1*a*, 1*b*, 1*c*.

Description.—Frond quadripinnate. Main rachis slightly flexuous, smooth. Primary pinnæ alternate, sub-deltoid, springing from the rachis at almost right angles, touching each other laterally or very slightly distant, and bearing eight or nine pairs of secondary pinnæ. Secondary pinnae deltoid, alternate, touching each other laterally, rachis slightly geniculate, smooth, and bearing four or five pairs of tertiary pinnæ. Tertiary pinnæ deltoid, with two or four pairs of pinnules. Fertile pinnules small, basal ones about 2 mm. long, alternate and bearing two alternate spreading

* See pl. lxxxi, figs. 1, 1*a*.

† *Cf.* pl. xxx, fig. 1*a*.

simple filiform-linear segments with a bifid terminal one ; upper pinnules bifid or simple according to their position on the rachis. Sporangia exannulate, oval, small, usually arranged in groups of four or five at the extreme apex of the ultimate divisions of the rachis, about 0·30 mm. long in greater diameter, with walls formed of small cells, slightly longer than broad. Sterile condition of plant unknown.

Remarks.—The most complete of the two British specimens of this species with which I am acquainted is that given natural size on Pl. LXXXI, fig, 1, a portion of which is enlarged two times at fig. 1*a*.

The fertile pinnules, the only ones known, are very small, and, as pointed out by POTONIÉ, have a great similarity to those of *Zeilleria delicatula* Sternb. sp. as figured by me in 1884,* but that species has a distinct narrow limb on each side of the midrib † when well preserved and there is no similar structure on the pinnules of *Renaultia germanica*, which consist of very narrow segments entirely deprived of a limb and have the appearance of being reduced to a slender rachis. The larger pinnules have usually only two simple lateral segments with a terminal one divided into two spreading arms, while the upper are reduced to a dichotomously divided segment, or are simple. The pinnules and their segments are wide spreading and give to the frond a rigid aspect.

The fructification is placed at the extremities of the pinnule segments, which appear to be slightly expanded, and consists usually of four or five stellately or irregularly arranged oval exannulate sporangia, whose attachment to the pinnule is obscured. The wall of the sporangium is formed of very small cells which are slightly longer than broad. The structure of the sporangia is not so well seen on the specimen given on Pl. LXXXI, fig. 1, as on a small example from No. 13 Callendar Pit, near Falkirk, where it is clearly exhibited.‡

POTONIÉ describes the sporangia as showing a mesh-like structure of raised up lines which, as shown in his figure 1*c*, are very irregular in size and run transversely across the sporangium, but he indicates doubt as to their representing the cells of the wall. Their direction and irregularity are more suggestive of lines caused by wrinkling. The cells of the sporangial wall are in fact much smaller than indicated on his figure.

On account of the sporangia being placed at the ends of the pinnule segments, POTONIÉ compared this fructification with that of *Sphenopteris* (*Hymenophyllites*) *quadridactylites* Gutbier, as described by ZEILLER,§ and assumed a generic relationship. He thus placed his plant in the genus *Hymenophyllites*, but in *Hymenophyllites quadridactylites* the sporangia are annulate whereas those of *Sphenopteris* (*Renaultia*) *germanica* are exannulate and therefore cannot be placed in the genus *Hymenophyllites*. In *Renaultia germanica*, moreover, the sporangia appear to have been developed in little stellate groups, though usually displaced, and there is no suggestion whatever

* *Quart. Journ. Geol. Soc.*, vol. xl, p. 592, pl. xxv, figs. 1–12.

† See ARBER, *Quart. Journ. Geol. Soc.*, vol. lix, p. 23, pl. ii, figs. 1, 2, 1903.

‡ Kidston Collection, No. 5888.

§ "Flore foss. bassin houil. de Valenciennes," pp. 56 and 100, pl. viii, figs. 1–3.

of the presence of a columella. As the sporangia individually have a similar structure to those of *Renaultia*, notwithstanding that the limb of the fertile pinnules seems to be almost if not entirely suppressed, I think that *Hymenophyllites* (*Sphenopteris*) *germanica* Potonié may find a place in the genus *Renaultia*, where it is here included.

Distribution.—*Renaultia germanica* is very rare and only known from the two localities mentioned below, both of which occur in the Lanarkian Series.

LANARKIAN SERIES.

Lanarkshire Coalfield.

Horizon: Kiltongue Coal. *Locality:* Ellismuir, Baillieston. In the "Dunlop Collection," Pittencrieff Museum, Dunfermline (Collected by Mr P. Jack).

Stirlingshire Coalfield.

Horizon: Main Coal. *Locality:* No. 13 Callendar Pit, ¼ mile S.S.E. of the Glen, $1\frac{1}{3}$ miles south of Falkirk.

Genus **Crossotheca** Zeiller.

1883. (August). *Crossotheca* Zeiller, *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, p. 180.
1888. *Crossotheca* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 33.
1911. *Crossotheca* Kidston, "Végét. houil. Hainaut Belge," *Mém. Musée roy. d'Hist. nat. Belgique*, vol. iv, p. 41.
1880. *Sorocladus* Lesqx. (*pars.*), "Coal Flora," vol. i, p. 327.
1883 (December). *Sorotheca* Stur, "Morph. u. Syst. der Culm- u. Carbonfarne," *Sitzb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, 807 (175) (fig. inaccurate).
1885. *Sorotheca* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 273 (fig. inaccurate).

Description.—Pteridospermous plants. Fertile and sterile pinnules dissimilar. Limb of fertile pinnule thick and probably of fleshy consistence, more or less oval or hastate in form, and attached to a stout pedicel. Microsporangia attached to the under surface of the pinnule, elongated, narrow, opening by a longitudinal cleft, in two cases at least bilocular. In the immature condition the free portions of the microsporangia are bent inwards, and their apices meet in the centre, forming a hemispherical sorus. At maturity the microsporangia separate and spread outwards, when they appear as a fringe surrounding the pinnule. Sterile foliage of the type of *Sphenopteris*, *Rhodea*, and *Pecopteris*.

Remarks.—The form of the individual microsporangia of *Crossotheca* is similar to those of *Telangium* Benson* and *Diplotheca* Kidston,† but in the case of these two genera the limb of the pinnule is reduced and merely forms a point for the attachment of the microsporangia. The microsporangia are also erect upon the

* *Telangium* Benson, *Ann. of Bot.*, vol. xviii, p. 161, pl. xi, 1904.
† *Diplotheca* Kidston, *Phil. Trans. Roy. Soc. Lond.*, ser. B, vol. cxcviii, p. 430, 1906.

little disc and do not appear as a downward hanging fringe. The long, narrow form of the microsporangia seen in *Crossotheca* appears to represent a type of microsporangia which, if not restricted to the Pteridosperms, is characteristic of them.

At least two species, *Crossotheca Hœninghausi* Brongt. sp. and *Crossotheca Hughesiana* Kidston, had bilocular microsporangia, but the structure of the microsporangia of the other species of the genus is not known. Zeiller, however, mentions that a slight furrow passes down the middle of the microsporangia of *Crossotheca Boulayi,* and suggests that it might indicate the union of two sporangia or the line of dehiscence. It is improbable that it represents the latter as it appears to occur on their outer surface. Is it not more probable that this furrow suggests the position of the septum that divides the microsporangium into two loculi ? From the great similarity in the structure of the sorus, the external form of the microsporangia, and their arrangement on the pinnule in the various members of the genus, it is not unlikely that all had bilocular microsporangia.

Figures illustrative of the sorus will be found in connection with the description of the British species.

The only seed that is known to belong to any member of the genus is that of *Crossotheca Hœninghausi* Brongt. sp., which has been described by Prof. Oliver and Dr Scott.*

Distribution.—The genus *Crossotheca* extends throughout the whole of the Upper Carboniferous, but with the exception of *Crossotheca Hœninghausi* Brongt. sp. and *Crossotheca Schatzlarensis* Stur sp., all the species are very rare.

Crossotheca Hœninghausi Brongniart sp.

Plate LXXXV, figs. 1, 2 ; Plate LXXXVI, figs. 1–13 ; Plate LXXXVII, figs. 4–10 ; text-figs. 22 and 23 (p. 332).

1828. *Sphenopteris Hœninghausi* Brongt., " Prodrome," p. 51.
1829. *Sphenopteris Hœninghausi* Brongt., " Hist. des végét. foss.," vol. i, p. 199, pl. lii.
1848. *Sphenopteris Hœninghausi* Sauveur, " Végét. foss. terr. houil. Belgique," pl. xxii, fig. 2.
1865. *Sphenopteris Hœninghausi* Andrae, " Vorwelt. Pflanzen," p. 13, pls. iv, v.
1869. *Sphenopteris Hœninghausi* Roehl, " Foss. Flora d. Steink. Form. Westph.," *Palæontographica,* Band xviii, p. 54, pl. xiv, fig. 8 (? pl. xiii, fig. 3).
1869. *Sphenopteris Hœninghausi* Schimper, " Traité de paléont. végét.," vol. i, p. 385, pl. xxix.
1879. *Sphenopteris (Hymen.) Hœninghausi* Lesqx., " Coal Flora," vol. i, p. 288, pl. lv, fig. 5.
1880. *Sphenopteris Hœninghausi* Zeiller, " Végét. foss. du terr. houil.," p. 41, pl. clxii, figs. 4, 5, *Explic. Carte Géol. France,* vol. iv.
1880. *Sphenopteris Hœninghausi* Achepohl, " Niederrh. Westfäl. Steink.," p. 26, pl. vi, fig. 1 ; Erganzungsblatt 1, fig. 39.
1882. *Sphenopteris Hœninghausi* Weiss, " Aus der Flora der Steinkohlenformation " (*K. preuss. geol. Landesanst.*), p. 13, pl. xi, figs. 68, 69 (*Zweiter Abdr.*).
1883. *Sphenopteris Hœninghausi* Renault, " Cours de botan. foss.," vol. iii, p. 191, pl. xxxii, figs. 1–3.

* Oliver and Scott, " On the Structure of the Palæozoic Seed *Lagenostoma Lomaxi,*" *Phil. Trans. Roy. Soc. London,* ser. B, vol. cxcvii, pp. 193–247, pls. iv–x, 1904.

1891. *Sphenopteris Hœninghausi* Kidston, " On the Fructification, etc., of Carboniferous Ferns," *Trans. Geol. Soc. Glasgow*, vol. ix, p. 48, pl. iv, fig. 44.

1899. *Sphenopteris Hœninghausi* Hofmann and Ryba, " Leitpflanzen," p. 41, pl. iv, figs. 7, 7*a*, 7*b*.

1901. *Sphenopteris Hœninghausi* Kidston, " Flora of Carboniferous Period," *Proc. Yorks. Geol. and Polytech. Soc.*, vol. xiv, p. 213, pl. xxix, fig. 5.

1905. *Sphenopteris Hœninghausi* White, " Fossil Plants of the Group Cycadofilices," *Smithsonian Miscellaneous Collections*, vol. xlvii, pt. 3, p. 383, pl. liii, fig. 2.

1909. *Sphenopteris Hœninghausi* Gothan, *Monatsber. deutsch. geol. Gesellsch.*, Band lxi, No. 7, p. 317.

1913. *Sphenopteris Hœninghausi* Gothan, " Oberschlesische Steinkohlenflora," Teil 1, *Abhandl. k. preuss. geol. Landesanst.*, N.F., Band lxxv, p. 58, pl. xiii, fig. 1 ; pl. xvii, fig. 2 (*pars*).

1886. *Sphenopteris* (*Calymmatotheca*) *Hœninghausi* Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 82, pl. v, fig. 3 ; pl. vi, figs. 1, 2.

1899. *Sphenopteris* (*Calymmatotheca ?*) *Hœninghausi* Zeiller, " Flore foss. du bassin houil. d'Héraclée " (*Mém. Soc. géol. France, Paléont.*, xxi), p. 10, pl. i, fig. 5.

1836. *Cheilanthites Hœninghausi* Göpp., " Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 244.

1877. *Calymmotheca Hœninghausi* Stur, " Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, p. 160 (266), Band viii.

1883. *Calymmotheca Hœninghausi* Stur, " Morph. u. Syst. d. Culm -u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 806.

1885. *Calymmotheca Hœninghausi* Stur, " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 258, pl. xxx, pl. xxxi, figs. 1, 2, 3.

1888. *Calymmotheca* (*Sphenopteris*) *Hœninghausi* Toula, " Die Steinkohlen," p. 188, pl. 1, fig. 14.

1905. *Crossotheca Hœninghausi* Kidston, *Proc. Roy. Soc. London*, Ser. B., vol. lxxvi, p. 358, pl. vi, figs. 1–5.

1906. *Crossotheca Hœninghausi* Kidston, " On the Microsporangia of the Pteridospermeæ," *Phil. Trans. Roy. Soc. London*, ser. B, vol. 198, p. 413, pl. xxv, figs. 1–16 ; pl. xxvi, figs. 17–32, text-figs. 1–7.

1911. *Crossotheca Hœninghausi* Johnson, " A Seed-bearing Irish Pteridosperm, *Crossotheca Hœninghausi* Kidston (*Lyginodendron Oldhamium* Williamson)." *Scientific Proc. Roy. Dublin Soc.*, vol. xiii (N.S.), No. 1, p. 1, pls. i–iii.*

1910. *Lyginopteris* (*Crossotheca*) *Hœninghausi* Schmitz and Deltenre in Renier, " Documents pour l'étude paléontol.," pl. lx, fig. *b* (? fig. *a*), pl. lxx ; pl. lxxx, fig. *b* (*pars*).

1826. *Sphenopteris asplenoides* Sternb., " Essai flore monde prim.," vol. i, fasc. iv, p. xvi ; vol. ii, fasc. v, vi, p. 62.

1869. Cf. *Sphenopteris distans* Roehl. (*non* Sternb.), " Foss. Flora d. Steink.-Form. Westph.," *Palæontographica*, Band xviii, p. 54, pl. xv, fig. 9.

Structure.

1866. *Dadoxylon Oldhamium* Binney, *Proc. Lit. and Phil. Soc. Manchester*, vol. v, p. 115 (Stem).

1869. *Dictyoxylon Oldhamium* Williamson, *Monthly Microsc. Journ.*, vol. ii, p. 66, pl. xx, figs. 3, 4.

1872. *Edraxylon* Williamson, *Proc. Roy. Soc. London*, vol. xx, p. 438, fig. 3 (Petiole).

1873. *Lyginodendron Oldhamium* Williamson, " Organisation of the Fossil Plants of the Coal Measures," pt. iv, *Phil. Trans. Roy. Soc. London*, p. 404, Plates.

1874. *Rachiopteris aspera* Williamson, Mem. VI, *Phil. Trans. Roy. Soc. London*, vol. 164, p. 684, Plates (Petiole).

1876. *Kaloxylon Hookeri* Williamson, Mem. VII, *ibid.*, vol. 166, p. 23, Plates (Root).

1887. *Kaloxylon Hookeri* Williamson, Mem. XIII, *ibid.*, Ser. B, vol. 178, p. 293, Plates.

1890. *Lyginodendron Oldhamium and Rachiopteris aspera* Williamson, Mem. XVII, *ibid.*, Ser. B, vol. 181, p. 89, Plates.

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* See Seward, " Fossil Plants," vol. iii, p. 51, 1917.

1891. *Lyginodendron Oldhamium* Solms-Laubach, "Fossil Botany," p. 358, fig. 49 (English Translation).
1895. *Lyginodendron Oldhamium* Williamson and Scott, "Further Observations on the Organisation of the Fossil Plants of the Coal Measures," *Phil. Trans. Roy. Soc. London*, Ser. B, vol. 186, p. 703, Plates.
1900. *Lyginodendron Oldhamium* Scott, "Studies in Fossil Botany," p. 308, figures; 2nd ed., vol. ii, p. 357, figures, 1909; 3rd ed., vol. ii, p. 21, 1923.
1899. *Lyginopteris Oldhamia* Potonié, "Lehrb. d. Pflanzenpal.," p. 170.
1900. *Lyginopteris Oldhamia* Zeiller, "Éléments de paléobot.," p. 128, fig. 96.
1917. *Lyginopteris Oldhamia* Seward, "Fossil Plants," vol. iii, p. 35 (figures).
1904. *Lagenostoma Lomaxi* Williamson MS., Oliver and Scott, "On the Structure of the Palæozoic Seed, *Lagenostoma Lomaxi*, etc.," *Phil. Trans. Roy. Soc. London*, Ser. B, vol. 197, p. 193, pls. iv–x.

Description.—Pteridosperm. Stem attaining a diameter of 4 cm. or more and giving off spirally-arranged petioles that depart at almost a right angle to the axis. Outer surface marked with rhomboidal areas formed by sub-epidermal anastomosing sclerenchymatous bands. In the centre of the rhomboidal areas are strong spine-like outgrowths, which on removal leave a small circular dot-like cicatrice.

Fronds tripinnate or quadripinnate, with dichotomously divided rachises which are also densely covered with spine-like outgrowths. Normal primary pinnæ are borne both below and above the dichotomies. Primary pinnæ sub-opposite or alternate, lanceolate or broadly lanceolate. Secondary pinnæ alternate, lanceolate, tapering gradually to a sharp point, rachis straight, where the frond is quadripinnate the tertiary pinnæ are short, the lowest sometimes subtriangular, the upper lanceolate and rather blunt-pointed.

Pinnules alternate, small, in outline orbicular or obtusely triangular, very convex when uncompressed but much more usually occurring flattened when the lobes are more prominent. Lower pinnules divided into 3–4 short rounded or truncate lobes, uppermost lobed or simple. The simple pinnules are frequently club-shaped and truncate. A central vein enters each pinnule, and gives off simple or forked lateral veinlets, one veinlet entering each lobe. The surface of the pinnules as well as of the rachises of various degrees bear irregularly placed spine-like outgrowths, some or all of which may have glandular heads.

Microsporangia borne on much modified oval pinnules of a thick or fleshy substance about 3 mm. long, pedicellate, the pedicel being united for some distance to the upper surface of the pinnule. A vein enters the pinnule which divides into two arms, but whether further divisions occur or not has not been observed. Microsporangia attached to lower surface, bilocular, fusiform, curved or falcate, with a sharp point, usually six in number, rarely seven.

In the immature condition the microsporangia are bent inwards and their apices meet in the centre to form a hemispherical sorus. At maturity they separate and spread outwards, having then the appearance of a fringe hanging from the margin of the limb. Dehiscence takes place by a longitudinal cleft which passes down the inner surface in a line parallel with the wall which separates the two loculi of the microsporangium. The microsporangia are about 3 mm. long and 1·5 mm. broad at their broadest part, which appears to be where they become free from the limb. Each of the loculi measures about 0·50 mm. in diameter. Microspores circular or slightly oval, with a diameter of 50 μ–70 μ and provided with a triradiate ridge. Their outer surface is roughened by numerous closely placed very minute blunt apiculi.

Seed small, 5·5 mm. in length and 4·25 mm. in maximum diameter and enclosed in an outer husk or cupule * which bears stalked glands similar to those of the pinnules and petioles.

Remarks.—A fragment of a stem is given natural size, on Pl. LXXXVI, fig. 4, which shows the rhomboidal areas formed by the sub-epidermal anastomosing sclerenchymatous bands. Probably these are more distinct in the fossil condition than during the life of the plant, through shrinkage and partial decay of the epidermal tissues. They are in any case characteristic of the stem of *Crossotheca Hœninghausi* Brongt. sp.

The specimen figured by ZEILLER as possibly a fragment of a primary rachis † is, I think, more probably a stem. The position of the structures it gives off rather favours this view, as they seem to depart in spiral series. ZEILLER himself refers to this in the description of his specimen, and suggests that it might be a stem rather than a primary rachis. The same explanation must, I think, be also given for the principal rachis of STUR.‡ If this opinion be correct the fronds of *Crossotheca Hœninghausi*, though they must have been of considerable size, did not attain to the dimensions that has sometimes been ascribed to them.

The petiole attained a width of 1·5 cm., if one correctly interprets the figure given by ZEILLER as a stem giving off spirally placed fronds. The mode of growth of *Crossotheca Hœninghausi* appears to be comparable with that of *Diplotmema elegans* Brongt. sp., and some other pteridosperms in so far as the stem probably gained support by scrambling among surrounding vegetation.§

The basal primary pinnæ are sometimes more distinctly deltoid in outline than those situated above them. This is well seen in one of ANDRAE's figures || and that given by STUR.¶ The same character has also been observed on British specimens. On basal pinnæ the pinnules are more developed and may possess 4–5 bifid or trifid lobes, or may be so much developed that they assume the appearance of small pinnæ. This is seen on the specimen shown on Pl. LXXXVII, fig. 4.

The pinnules vary in size from 1 mm. to 3 mm. and also considerably in their appearance in the fossil state, attributable in part to different modes of preservation and the amount of pressure and flattening out that has taken place. When uncompressed they are very convex and have 3–4 inflated little rounded lobes as seen at Pl. LXXXV, figs. 1, 1*a*, and Pl. LXXXVI, fig. 9, into each of which a veinlet

* SCOTT, "Studies in Fossil Botany," vol. ii, p. 386, 2nd ed., 1909; 3rd ed., vol. ii, p. 63, 1923.

† "Flore foss. bassin houil. de Valenciennes," pl. vi, fig. 1.

‡ "Carbon-Flora der Schatzlarer Schichten," pl. xxxi, figs. 1, 2.

§ See *ante* p. 87 and p. 245.

|| "Vorwelt. Pflanzen," pl. iv, fig. 1, 1865.

¶ *Loc. cit.*, pl. xxx, fig. 1.

extends. On the specimens more frequently met with the pinnules are more or less flattened and the convex character of the pinnules entirely effaced. When the pinnules are flattened out the segments are frequently seen to be somewhat truncate. This is illustrated in the three small specimens preserved in ironstone nodules given enlarged two times at Pl. LXXXVI, figs. 1–3. All these variations in form of pinnule pass into one another and seem to represent only individual differences of development and position on the frond as well as varying conditions of preservation. Another specimen which shows the lobes of the pinnules flattened out is given at fig. 2, Pl. LXXXV ; of which a part is enlarged two times at fig. 2*a*, where the segments have a truncate appearance.

Some specimens show a more lax growth than others where the pinnules are more distant and their segments further apart. Such an example is given at fig. 4, Pl. LXXXVII, where also the segments have bluntly rounded apices.

At fig. 8, Pl. LXXXVI, an ultimate pinna of *Crossotheca Hœninghausi* Brongt. sp. is given enlarged four times to show the presence of the spine-like glands on the pinnules. They are seen chiefly towards the ends of the segments and on specimens occurring in the coal-balls of Yorkshire and Lancashire ; where their structure is preserved they are very frequently shown on sections of the pinnules. *

Several figures are given of the fertile condition, all of which, except fig. 5, are from specimens collected by Mr H. W. Hughes. Fig. 7, which is two times enlarged, shows on the same pinnæ the organic connection of fertile and sterile pinnules. The fertile pinnules are especially well seen on the upper part of the pinna on the right side of the specimen, which also bears a sterile pinnule at its base. The sterile pinnules here seem to have undergone a slight reduction. Sterile basal pinnules succeeded by fertile ones are also well seen on the two pinnæ on the left side. All the pinnules on the upper part of the specimen appear to have been fertile.

Fig. 12 shows a few immature sori enlarged two times. The individual microsporangia bend inwards and their apices meet in the centre. At fig. 11, Pl. LXXXVI, the upper surface of some fertile pinnules are shown enlarged two times. Here from their small size they appear to be immature. The surface is faintly striated, but this may be caused by shrinkage. A portion of the same example is given at fig. 11*a*, enlarged four times, where their form is more clearly seen.

The lamina seems to have been much thicker and more fleshy than that of the ordinary foliage pinnules. This is shown at figs. 5, 6*a*, and 11 of the same plate.

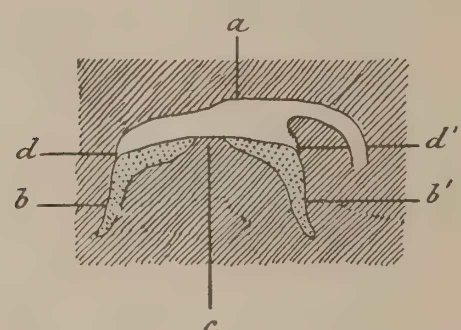
Mature sori are given at figs. 5, 6, 6*a*, and 7, Pl. LXXXVI. The terminal sorus of fig. 5, which is enlarged two times, shows the attachment of the pedicel to the limb, and indications of dichotomous nervation are visible on its surface. At fig. 6 is a small pinna, natural size, which is enlarged four times at fig. 6*a*. The nodule containing this fossil has so split that the cleft has passed longitudinally through most of the microsporangia, which thus exhibit the inner surface of the sporangial wall where the longitudinal cleft by which dehiscence took place can be clearly observed,

* See Kidston, *Phil. Trans.*, ser. B, vol. 198, p. 415, fig. 2, 1906.

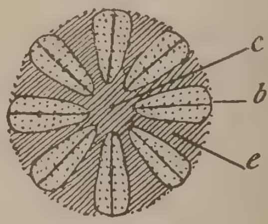
and dehiscence clefts are especially well exhibited at *a* and *a′*, if the figure be examined with a lens.

The form of the microsporangia is seen at the base of the specimen shown at fig. 5, which is enlarged two times, and at fig. 6*a* and 13, which are enlarged four times. They are falcate, about 3 mm. long and 1·5 mm. wide at their base, and terminate in a sharp point.

Many of the microsporangia contained the microspores. When unshrunk they are globular or slightly oval and possess a well-marked triradiate ridge, showing that they were tetrahedrally developed. Their outer surface is roughened with minute apiculi. Most of the spores, however, are now found in a crumpled condition and many are probably more or less immature. They measure on an average 50 μ to 70 μ in



TEXT-FIG. 22.—*Crossotheca Hœninghausi* Brongniart sp. and *Crossotheca Hughesiana* Kidston. Diagrammatic section. Explanation in text.



TEXT-FIG. 23.—*Crossotheca Hœninghausi* Brongniart sp. and *Crossotheca Hughesiana* Kidston. Explanation in text.

diameter. A few are given on Pl. LXXXVII, figs. 5–10, enlarged five hundred times, to show the variation in their size.

The restoration of a sorus, given in radial section at text-fig. 22 and in transverse section at text-fig. 23, explains the mode of preservation of the specimens just described. At text-fig. 22, *a*, is seen the limb or pinnule, at *b* and *b′* two of the microsporangia. The part of the matrix lettered *c* is the central boss with which the ridges unite in figs. 8 and 10, Pl. LXXXVIII (*Crossotheca Hughesiana*). It is also seen in figs. 6*a* at *a*, Pl. LXXXVI (*Crossotheca Hœninghausi*). The rays in these figures represent the space between the microsporangia and cannot be shown in a radial section, but if a transverse section be made in the line of *d*, *d′*, text-fig. 22, as shown in text-fig. 23, there is represented the condition shown in some of the specimens. Here *c* represents the boss of rock, *e* the rays, and *b* the bilocular microsporangia. This figure represents the condition shown at figs. 8E *b* and 10 *i*, Pl. LXXXVIII. The microsporangia therefore appear to have been quite free from each other or from any central point to which they were mutually attached.

The seed has been found in the coal-balls of Lancashire. It possesses a complex organization, and is surrounded by an outer husk or cupule which bears glandular spines similar to those occurring on the rachises and pinnules.

It does not fall within the scope of this Memoir to describe the internal organization of plants included in it even when that is known, but in the literature and synonymy of *Crossotheca Hœninghausi* (quoted on p. 328), there have been included references to the more important descriptions dealing with the internal organization of the plant.

It would be difficult to confuse *Crossotheca Hœninghausi* Brongt. sp. with any other Upper Carboniferous plant. Its small pinnules and the rough spiny stem and rachises and Lyginodendroid cortex afford distinctive characters, and even when the spines are not prominently shown, the small lobed pinnules will distinguish it from any of the other species with which it occurs.

Potonié * has united *Calymmotheca Stangeri* Stur,† *Calymmotheca Larischi* Stur,‡ *Calymmotheca Schlehani* Stur,§ and *Calymmotheca Rothschildi* Stur || with *Crossotheca Hœninghausi* Brongt. sp. as varieties of it, but I cannot accept any of these as varieties of *Crossotheca Hœninghausi*, which is clearly specifically distinct.

From *Calymmatotheca* (*Calymmotheca*) *Stangeri*, *Crossotheca Hœninghausi* differs in the form of the cupule by which the seed has been enveloped, the pinnules are more solid, and the whole plant has a denser growth. In *Sphenopteris* (*Calymmotheca*) *Larischi* Stur the pinnules are more deeply segmented, more spreading, and the rachis does not appear to have possessed the extreme spiny character of *Crossotheca Hœninghausi*. *Calymmatotheca Rothschildi* is only a form of *Calymmatotheca Stangeri* and is united with that species, to which most probably *Calymmotheca Schlehani* also belongs.

As pointed out by Stur,¶ the figure of *Sphenopteris elegans* given by Roehl ** and also that of *Sphenopteris distans* of the same author †† may belong to *Crossotheca Hœninghausi*, but both figures are very unsatisfactory.

The specimen figured by Feistmantel under the name of *Sphenopteris Hœninghausi* in his "Verstein. d. Böhm. Kohlenab.," Abth. iii, p. 57, pl. xvi, fig. 2, possibly belongs to the species named, but if so, the figure is not very satisfactory. On the other hand, the small specimen this author identifies as *Sphenopteris Hœninghausi* from near Rothwaltersdorf ‡‡ must be referred to *Sphenopteris Bermudensiformis* Schlotheim sp. (*Sphenopteris distans* Sternb.).

It is extremely doubtful that the example figured by Geinitz §§ as *Sphenopteris Hœninghausi* belongs to that plant. The enlargement he gives is not taken from the specimen given at his fig. 5, but is a rather inaccurate copy of the enlargement given by Brongniart.

* "Ueber einige Carbonfarne," pt. ii, *Jahrb. k. preuss. geol. Landesanstalt für 1890*, p. 16, pls. vii–ix, 1891.
† "Culm Flora," pl. xxv, figs. 2–4; pl. xxvi.
‡ *Loc. cit.*, pl. xxvii; pl. xxviii, fig. 1.
§ *Loc. cit.*, pl. xxviii, figs. 2–4.
|| *Loc. cit.*, pl. xxviii, fig. 5.
¶ "Carbon-Flora der Schatzlarer Schichten," p. 257.
** "Foss. Flora Steink. Form. Westphalens," pl. xv, fig. 8.
†† *Loc. cit.*, pl. xv, fig. 9.
‡‡ Feistmantel, *Zeitschr. deutsch. geol. Gesellsch.*, Band xxv, p. 504, pl. xiv, fig. 7, 1873.
§§ "Verstein. d. Steinkohlf. in Sachsen," pl. xxiii, fig. 5.

The *Sphenopteris Hœninghausi* L. and H.* is specifically distinct from Brongniart's plant of that name and has been renamed *Sphenopteris effusa*.†

Distribution.—Crossotheca Hœninghausi Brongt. sp. occurs both in the Westphalian Series and the Lanarkian Series. It is very irregularly distributed and from several of the coalfields has not been recorded. In some where it has been met with it is rare, while in the coal-balls of Lancashire and Yorkshire it is very common, and at Tullygarth Pit, near Clackmannan, it was so abundant in a band of blaes passed through when sinking the shaft that it was suggestive of the plants having grown in a dense mass or thicket.

WESTPHALIAN SERIES.

North Derbyshire and Nottingham Coalfield.

Horizon: Between Top Hard Coal and Deep Soft Coal. *Locality:* Newthorp Clay Pit, Eastwood (Dr L. Moysey).

Horizon: ? *Locality:* Oakwell Brickyard, Ilkeston (Collection of Geological Survey, London).

Northumberland and Durham Coalfield.

Horizon: Stone Coal. *Locality:* Chopwell, near Ebchester (W. Eltringham).

Horizon: Three-quarter Seam. *Locality:* Chopwell, near Ebchester (P. Charlton).

North Wales Coalfield.

Horizon: Roof of Wall and Bench Coal. *Locality:* Bryn-mally Colliery, 2¾ miles N.N.W. of Wrexham, Denbighshire (Collection of Geological Survey, London).

South Staffordshire Coalfield.

Horizon: Immediately below Bottom Coal. *Locality:* Ruiton, near Sedgley.

Horizon: Roof of Brooch Coal. *Locality:* Pensnett, 2 miles south-west of Dudley.

Horizon: Roof of Fireclay Coal. *Locality:* Netherton, near Dudley (H. W. Hughes).

Horizon: Bed between Fireclay Coal and Bottom Coal. *Locality:* Doulton's Clay Pit, Netherton, near Dudley (H. W. Hughes).

Horizon: Ten-foot Ironstone Measures. *Localities:* Clayscroft openwork, Coseley, near Dudley (H. W. Hughes); Ettingshall.

South Wales Coalfield.

Horizon: Five-foot Seam—Seven-foot Seam of Clydach Vale. *Locality:* Britannic Collieries, Gilfach Goch, Glamorganshire (D. Davies).

* "Fossil Flora," vol. iii, pl. cciv.

† See *ante* p. 100.

Horizon: ? *Locality:* Shore, Cliffs just above "private" path leading from beach to St Brides House and 200 yards S.S.E. of Saundersfoot Harbour, Pembrokeshire (Collection of Geological Survey).

Yorkshire Coalfield.

Horizon: Better Bed Coal. *Locality:* Clifton, $4\frac{1}{2}$ miles north of Huddersfield (Victoria Museum, Brighouse).

Horizon: Black Bed Coal. *Locality:* Hartshead Moor Colliery, near Halifax (R. Renton).

Horizon: White Rake Bed. *Locality:* Low Moor, near Bradford (J. Davies).

LANARKIAN SERIES.

Clackmannan Coalfield.

Horizon: ? *Locality:* Tullygarth Pit, near Clackmannan.

Midlothian Coalfield.

Horizon: Diamond Seam. *Locality:* Whitehall Colliery, Rosewell.

Horizon: ? *Locality:* River South Esk, left bank at point south-west of Newmills Bridge and west of Brewlands, Dalkeith (Collection of Geological Survey, Edinburgh).

Stirlingshire Coalfield.

Horizon: Ball Coal. *Localities:* Meadowbank Pit, $\frac{1}{2}$ mile south of Polmont (Collection of Geological Survey, Edinburgh); Callendar Pit, $\frac{1}{4}$ mile S.S.E. of the Glen, $1\frac{1}{3}$ miles south of Falkirk (Collection of Geological Survey, Edinburgh); No. 23 Pit, Redding, near Polmont (C. M'Luckie).

Lancashire Coalfield.

Horizon: Coal-balls in Hard Bed Coal. *Localities:* Colne Oldham, Littleborough, $3\frac{1}{4}$ miles north-east of Rochdale.

Northumberland and Durham Coalfield.

Horizon: Cowley Coal, 27 fathoms below Cowley Seam. *Locality:* Woodland Colliery, Durham (Sedgwick Museum, Cambridge).

Yorkshire Coalfield.

Horizon: Coal-balls in Hard Bed Coal. *Localities:* Halifax; Fieldhouse Colliery, Deighton, near Huddersfield; Bullhouse Colliery, Penistone.

Crossotheca Hughesiana Kidston.

Plate LXXXVIII, figs. 1–10; text-figs. 22 and 23 (p. 332); text-figs. 24 (p. 337), and 25 (p. 338).

1906. *Crossotheca Hughesiana*, Kidston, *Phil. Trans. Roy. Soc. Lond.*, ser. B, vol. 198, p. 424, pls. xxvii–xxviii.

Description. — Pteridosperm. Frond tripinnate or possibly quadripinnate. Fertile primary pinnæ broadly lanceolate, rachis straight, faintly striated longitudinally. Secondary pinnæ alternate, lanceolate to broadly lanceolate; rachis straight, faintly striated longitudinally, with five or more pairs of alternate pinnules. Pinnules cordate, obtuse, about 5 mm. long and 5 mm. broad at their widest part, with long pedicels. Pedicels joined to the upper surface of the limb of the pinnule. The vein springs from the extremity of the pedicel and apparently divides first into two close parallel branches from which veinlets go off unilaterally. Pinnules bear from six to nine bilocular microsporangia about 3 mm. long, free, falcate, terminating in a sharp point and attached to the pinnule by their broad basal portion. Dehiscence takes place by a longitudinal cleft which passes down their adaxial surface in a line parallel with the central band which separates the two loculi. When immature the microsporangia are bent inwards and their apices, meeting in the centre, form a hemispherical sorus. At maturity they spread outwards and extend beyond the margin of the pinnule as a fringe. The microspores are circular or slightly oval with triradiate ridge and outer surface roughened by very minute spiculi. They vary slightly in size and are from 50 μ to 55 μ in diameter. Sterile condition of frond unknown.

Remarks.—On Pl. LXXXVIII several specimens of *Crossotheca Hughesiana* are figured to illustrate the structure of the sorus.

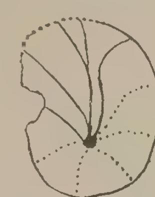
Fig. 6 shows the lower portion of possibly a primary pinna and represents the earliest stage of development of the sori met with. The principal rachis is very stout, being 4 mm. broad and is longitudinally striated. It gives off alternate secondary pinnæ with proportionally thick rachises which in turn bear stalked, fertile pinnules. The microsporangia are immature, bent inwards, and form small globular, apple-like structures. Through the occasional disappearance of the outer wall of the microsporangia, the loculi are distinctly seen at many points on this specimen, and reveal the yellow spores with which they are filled.

An upper portion of what is also regarded as a primary pinna is seen at fig. 4, which, taken in connection with the basal portion given at fig. 6, illustrates well the general form of the primary pinnæ.

Another portion of the apex of a primary pinna is given at figs. 2 and 2*a* which show the two halves of the same nodule. The remains of the plant have entirely disappeared and the specimen merely shows its impress on the split surfaces of the nodule. That seen at fig. 2 shows the impression of the upper surface of the pinnules, of which a portion is enlarged two times at fig. 2*c* where their cordate form is distinctly seen. Here the vein can be observed to enter the limb a short distance from its margin, where it divided into two branches.

On another small example enlarged two times at fig. 10*a*, the upper pinnule shows additional veins being given off from the base of the central vein as represented at text-fig. 24. Other veinlets were probably supplied somewhat in the manner indicated by the dotted lines on the text-fig.

This small glimpse of the nervation of the fertile pinnules is of interest, for if we are correct in believing that veins once occupied the positions of the dotted lines in the text-fig. 24, there cannot have been more than 8–9 veinlets in the pinnules, which thus correspond in number with the sporangia on the larger sori, and would seem to indicate that each bilocular microsporangium was situated on a veinlet.



TEXT-FIG. 24.—*Crossotheca Hughesiana* Kidston. Nervation of fertile pinnule, enlarged.

The immature sori on the impression given at fig. 2*a* have the form of small hemispheres, on whose surface are a number of longitudinal lines which converge to a point at its centre. These converging lines mark off the individual microsporangia forming the sori, which in a further state of development will separate and spread outwards (fig. 2*b*).

The usual number of microsporangia that go to form a sorus is eight, but six and nine have been observed in some cases.

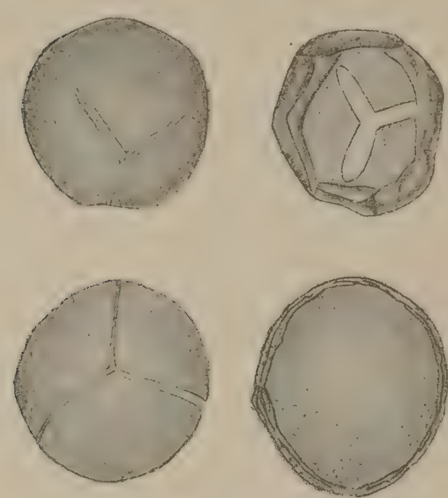
The infolding of the microsporangia is beautifully seen at fig. 3, which is enlarged two times. The microsporangia here have reached a more advanced state than those last described. They are falcate, have a broad base, and contract gradually upwards into a sharp point.

The two examples seen at fig. 1, natural size, and at fig. 5, which is enlarged two times, had probably reached maturity and shed their spores as the sporangia spread outwards beyond the limb. This is especially well seen in fig. 5. The fracture, which has divided the nodule into two, has passed more or less longitudinally through many of the microsporangia and has brought to view the inner surface of the adaxial wall on which the longitudinal line of dehiscence can be distinctly seen.

As the limb of the pinnule has entirely disappeared from the fertile pinnules, seen at fig. 7, the complete form of the falcate microsporangia is well shown at *a*.

That the microsporangia were free and in no way united to each other is clearly demonstrated by many specimens, and a single sorus is enlarged two times at fig. 8 to illustrate this point. This example shows the hollow left in the matrix which was originally occupied by the sorus, but from which all the organic matter has been removed (fig. 8*b*). The ridges *c* that radiate from a central solid boss *a* are formed by the matrix which separated the individual microsporangia, while the hollows that lie between them *b* and pass down into the stone are the now empty cavities which were once occupied by the microsporangia. It will be noticed that these cavities all terminate against the central boss of matrix *a* and are quite free from each other. The lower surface of the limb of the pinnule to which the microsporangia were attached by their basal portions originally rested on this impression, but, like the organic matter of the microsporangia, it has entirely disappeared and thus revealed the hollows left in the matrix by the latter (see text-fig. 23).

The same explanation applies to figs. 10 and 10*a* which show the corresponding part of the two surfaces of the same nodule, fig. 10*a* fitting on to fig. 10. The hollows and ridges seen on the sori lettered *i*, *i*, fig. 10, have been brought about in a similar manner to those described above in explanation of fig. 8. Fig. 10*a* shows the impression of the upper surface of the same pinnules. This exhibits the attachment of the pinnules to their foot-stalks, and in some of them the two parallel central veins, which are shown from another specimen in text-fig. 24. The attachment of the pedicel to the limb is exhibited on the terminal pinnule of the ultimate pinna, given at fig. 9, where it appears to extend over and beyond the margin of the pinnule before becoming united to the surface.



TEXT-FIG. 25.—*Crossotheca Hughesiana* Kidston. Microspores × 500.

Four microspores, enlarged five hundred times, are shown at text-fig. 25. They are circular or slightly oval, have a prominent triradiate ridge, and their outer surface is roughened with minute apiculi.

Crossotheca Hughesiana is closely related to *Crossotheca Hœninghausi*, but is distinguished by the larger size of the fertile pinnules, whose limb also is more distinctly cordate.

My thanks are due to Mr H. W. HUGHES, F.G.S., for kindly lending me the specimens figured on Pl. LXXXVIII.

Distribution.—Crossotheca Hughesiana has only been found at the undernoted locality, where, however, a considerable number of specimens have been collected.

WESTPHALIAN SERIES.

SOUTH STAFFORDSHIRE COALFIELD.

Horizon : Ten-foot Ironstone Measures. *Locality :* Clayscroft openwork, Coseley, near Dudley, Staffordshire.

Crossotheca Schatzlarensis Stur sp.

Plate LXXXIX, figs. 1–8; text-fig. 26 (p. 340).

1883. *Calymmotheca Schatzlarensis* Stur, " Morph. u. Syst. d. Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 803 (171) (fig. 36 inaccurate).

1885. *Calymmotheca Schatzlarensis* Stur, " Carbon-Flora der Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 265, pl. xxxviii, figs. 1, 2 (text-fig. 40, p. 238, inaccurate).

1888. *Crossotheca Schatzlarensis* Kidston, " Fructification of Two Coal Measure Ferns," *Proc. Roy. Phys. Soc. Edin.*, vol. ix, p. 516.
1888. *Crossotheca Schatzlarensis* Kidston, *Ann. and Mag. Nat. Hist.*, ser. 6, vol. ii, p. 27.
1913. *Crossotheca Schatzlarensis* Carpentier, " Contrib. à l'étude du Carbon. du Nord de la France," *Mém. Soc. géol. du Nord*, vol. vii, p. 380, pl. ix, fig. 3.
1899. *Sphenopteris* (*Crossotheca*) *Schatzlarensis* Zeiller, " Étude sur la Flore foss. bassin houil. d'Héraclée " (*Mém. Soc. géol. France, Paléont.*, xxi), p. 13, pl. ii, fig. 7.
1910. *Sphenopteris* (*Crossotheca*) *Schatzlarensis* Deltenre in Renier, " Documents pour l'étude paléont.," pl. lxix.
1888. *Crossotheca fimbriata* Kidston (*op. supra cit.*), p. 511, pl. xxi, figs. 1–8.
1888. *Crossotheca fimbriata* Kidston, *Ann. and Mag. Nat. Hist.*, ser. 6, vol. ii, p. 23, pl. i, figs. 1–8.

Description.—Pteridosperm. Frond very large, quadripinnate, main rachis stout, smooth or faintly striated, 1 cm. broad. Primary pinnæ lanceolate, rachis straight, stout, 0·5 cm. in width, smooth or faintly striated. Secondary pinnæ alternate, lanceolate, rachis straight, about 1 mm. broad. Sterile tertiary pinnæ alternate, broadly lanceolate or oblong. Pinnules alternate, and divided into 1–3 pairs of distant, simple or furcate, narrow spreading segments, into each of which a single vein extends.

Fertile pinnules alternate, pedicellate, limb developed in the form of a disc, to whose upper surface the pedicel is attached. Microsporangia small, falcate, with a broad base and tapering to a point at the apex, about 1·5 mm. long and at base 0·5 mm. broad, attached to the lower surface of the disc, six to eight microsporangia entering into the formation of a sorus. In the immature condition the apical portions of the microsporangia are bent inwards and, meeting in the centre, form a small hemispherical group. At maturity the microsporangia separate and, spreading more or less outwards, appear as a fringe to the disc-like limb of the pinnule.

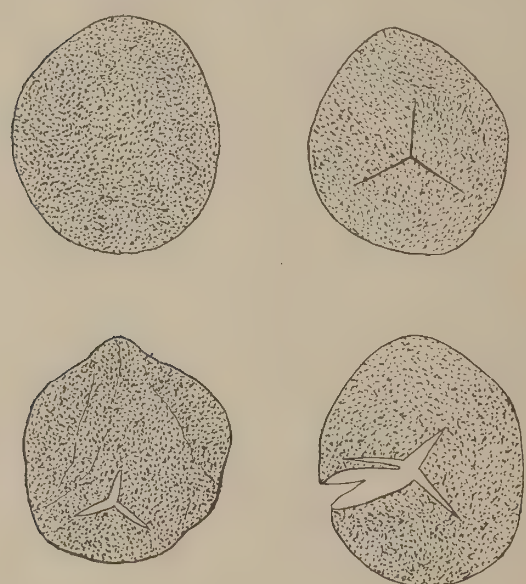
Microspores circular, small, smooth, with a triradiate ridge, and measuring about 60 μ in diameter. Seed unknown.

Remarks.—From the large size attained by *Crossotheca Schatzlarensis* Stur sp. and the small and delicate divisions of its pinnules it must have been an exceedingly graceful plant. The main rachis and those of the primary pinnæ were, however, exceptionally thick and must have been in strange contrast to the delicate pinnules of the sterile portion of the frond. A small specimen received from Mr W. Hemingway shows what is apparently a fragment of the rachis of a primary pinna 0·5 cm. thick, and yet this gives off secondary pinnæ of which the rachis is only 1 mm. broad. These thick rachises associated with the more delicate ones and the finely divided pinnules must have imparted to the plant a distinctive appearance, of which one can gain some idea from the figure given by Stur in his " Carbon-Flora der Schatzlarer Schichten," pl. xxxviii, fig. 2.

A small sterile specimen is shown natural size on Pl. LXXXIX, fig. 1, and two pinnules are enlarged three and a half times at fig. 1*a* to show the nervation and the narrow linear segments into which they are divided. The sterile pinnules are of a similar type of structure and segmentation to those of the plants included in the form genus *Rhodea,* and it is on account of its fructification that it is placed in *Crossotheca.*

Another small specimen of a sterile pinna is given at fig. 2. The rachis is 2·5 mm. broad, and a penultimate pinna given off from it is about 1 mm. in width. On this fragment the ultimate pinnæ and pinnules are more closely placed than on that given at fig. 1, which causes the pinnæ to have a more dense appearance ; otherwise it agrees in all respects with the usual form of the species.

The upper surface of the pinnules of both specimens seen at figs. 1, 2, is roughened. When examined under the microscope this is seen to be caused by the narrow elongated cells of the epidermis and is not due to the presence of small adpressed hairs. No attempt has been made to indicate this roughening on the enlarged pinnules at fig. 1*a*. This cellular structure can only be seen on specimens preserved under favourable conditions and is not observable on all examples of the species. The fertile condition of *Crossotheca Schatzlarensis* is seen natural size at figs. 3, 4. These are possibly fragments of secondary pinnæ. The pinnules are alternate and long-stalked, and the peltate limb, to whose lower surface the microsporangia were attached, must have been of considerable thickness if one may judge from the amount of coaly matter they possess in the fossil state. The pedicel is adnate to the upper surface of the pinnule, but in the mature condition of the sorus this is not usually exhibited, as a shrinkage of the tissue of the limb seems to have taken place. On such specimens as those enlarged at figs. 5, 6, one would almost think the pedicel was attached to the centre of the under side of the limb. This appearance is produced by a collapse of the tissue of the limb or by the sorus lying on and obscuring the upper part of the pedicel.



TEXT-FIG. 26. — *Crossotheca Schatzlarensis* Stur sp. Microspores enlarged 500 times. Locality: Ward Green, Barnsley. Horizon: Barnsley Coal.

In the young condition, however, before the sporangia open out, the relationship of the pedicel to the limb can be clearly observed, as seen at figs. 7 and 8, which are enlarged about four times. The attachment of the pedicel to the sorus is especially well seen at fig. 7. Here it extends to the centre of the disc and seems to be organically united to it throughout the whole distance from the margin to the point at the centre where it terminates. Fig. 8 does not so clearly exhibit this relationship, but so far confirms the view of the complete union of the pedicel with the disc.

In some fertile specimens of *Crossotheca Schatzlarensis* which were contained in ironstone nodules found at Ward Green, Barnsley, in the roof of the Barnsley Coal by Mr W. HEMINGWAY, the microspores were in a beautiful state of preservation. They are circular, with granular or minutely apiculate outer surface and a triradiate ridge, and measure about 60 μ. Some microspores are given at text-fig. 26, enlarged five hundred times.

Each sorus bore about six mirosporangia, though in some cases there may have been eight. It is, however, frequently difficult to determine the exact number.

The structure of the sori of *Crossotheca Schatzlarensis* shows that it is a pteridosperm, though the seed has not yet been discovered.

The British specimens of *Crossotheca Schatzlarensis* Stur sp. were originally described as a new species under the name of *Crossotheca fimbriata*, but subsequently on receiving authentic specimens of STUR's plant from the late M. F. CRÉPIN it was found on comparison that the British and Belgian fossils were identical. The cause of my separating the British examples from *Crossotheca Schatzlarensis* was the important difference in the structure of the fructification as described and illustrated in the enlarged figure given by STUR (*loc. cit.*), but this figure has been shown to be inaccurate. In the fructification of *Crossotheca Schatzlarensis* one is dealing with microsporangia, whereas these were interpreted by STUR as segments of a capsule ("*Indusienkapsel*"), and as such he represented them in his enlarged figure, evidently having been misled through the imperfect preservation of his specimens.

In the sterile condition, *Crossotheca Schatzlarensis* could not be easily mistaken with any other Upper Carboniferous species, the long, narrow filamentous segments of the pinnules being very distinctive. The fruiting pinnules, however, have a great similarity to those of *Crossotheca Hœninghausi* Brongt sp., but are smaller. In *Crossotheca Schatzlarensis* the largest mature sori when fully expanded are rather under 3 mm. wide even in a flattened condition, whereas those of *Crossotheca Hœninghausi* are rather over 3 mm. in width. But in addition to the difference in size between the sori of the two species, those of *Crossotheca Schatzlarensis* are much more delicate and have not the solidity of those of *Crossotheca Hœninghausi* Brongt. sp.

Distribution.—Except in the Yorkshire Coalfield, *Crossotheca Schatzlarensis* Stur sp. is rare in Britain. It is only known to occur in the Westphalian Series.

WESTPHALIAN SERIES.

LANCASHIRE COALFIELD.

Horizon: Shales associated with Ravenhead Coal. *Locality:* Ravenhead, near St Helens (Liverpool Museum).

LEICESTERSHIRE AND SOUTH DERBYSHIRE COALFIELD.

Horizon: Roaster Coal. *Locality:* Whitwick, Coalville (A. R. HORWOOD).

North Derbyshire and Nottingham Coalfield.

Horizon: Below Top Hard Coal. *Locality:* Shipley Clay Pit, Ilkeston, Derbyshire (Dr L. Moysey).

Horizon: Top Hard Coal. *Locality:* Digby Clay Pit, Kimberley, Nottinghamshire.

Yorkshire Coalfield.

Horizon: Top Beamshaw Coal. *Locality:* Oaks Colliery, near Barnsley (W. Hemingway).

Horizon: Rock below Haigh Moor Coal. *Locality:* Brightside, near Sheffield (W. Hemingway).

Horizon: 128 feet above Shafton (?) Coal. *Locality:* Bentley Colliery Sinking, 2½ miles north of Doncaster (H. Culpin).

Horizon: Barnsley Rock over Barnsley Coal. *Locality:* Cooper's Pit, Worsborough Dale, near Barnsley (W. Hemingway).

Horizon: Barnsley Coal. *Localities:* South Kirkby Colliery, near Pontefract (W. Hemingway); Fence Colliery, Woodhouse Mill, near Rotherham (W. Hemingway); East Gawber Colliery, near Barnsley (W. Hemingway); Monckton Main Colliery, near Barnsley (W. Hemingway); Woolley Colliery, Darton, near Barnsley (W. Hemingway); Ward Green, near Barnsley (W. Hemingway); Kilnhurst Pit, Rotherham (C. Bradshaw).

Horizon: Warren House Coal. *Locality:* Glasshoughton Pit, Castleford (Dr Wellburn).

Horizon: White Rake Bed. *Locality:* Low Moor, near Bradford (J. Davis).

Crossotheca communis Lesquereux sp.

Plate LXXXIX, figs. 9, 9*a*–9*c*, 10, 10*a*.

1884. *Sphenopteris communis* Lesqx., "Coal Flora," vol. iii, p. 762, pl. civ, figs. 1, 1*a*.
1895. *Sphenopteris communis* Kidston, "Occurrence of *Sphenopteris communis* Lesqx. in Britain," *Proc. Roy. Phys. Soc. Edin.*, vol. xiii, p. 87, pl. i, figs. 1–5.

Description. — Pteridosperm. Frond quadripinnate, main rachis apiculate. Primary pinnæ oblong-lanceolate. Secondary pinnæ oblique, oblong-lanceolate, contracting in upper part to a point, close, free or margins slightly overlapping, rachis straight and narrowly winged. Tertiary pinnæ alternate, oblique, oblong with blunt apices close, touching laterally or slightly separated, rachis straight, winged; the larger bearing about six pairs of pinnules. As the tertiary pinnæ are traced upwards, the pinnules become more and more united to each other and the smaller apical pinnæ assume the form of crenate pinnules. Sterile pinnules alternate, oblique, oval or oblong obtuse at apex and more or less united to each other; those on the pinnæ holding a lower position on the frond have crenate margins, free except at their base, where they are united by a narrow decurrent wing, those placed above them on the same pinna and those on pinnæ holding a higher position, more united to each other and less distinctly crenate; apical pinnules confluent, usually entire, terminal pinnule obtuse. Upper surface of pinnules with a rough striated appearance. The central slightly flexuous vein gives off simple or dichotomously divided veinlets which extend to the margin of the pinnule.

Fertile pinnules reduced to the form of a disc-like structure to whose lower surface the microsporangia are attached.

Remarks.—The upper surface of the pinnules of *Crossotheca communis* has a rough striated appearance, which is as distinctly seen on two examples from Arkansas, received from the late Mr R. D. LACOE, as on those from the South Staffordshire Coal-field, though this character is not referred to by LESQUEREUX.

In the account I originally gave of the British specimens, I ascribed the roughness on the surface of the pinnules to the probable presence of short, rigid, adpressed hairs. I now rather incline to the view that the short, close, raised-up hair-like striæ on their surface may be caused by prominent rows of epidermal cells, like those on the pinnules of *Sphenopteris spiniformis* * but whatever the cause of their rough surface the pinnules have the appearance represented at fig. 9*c*.

The sterile pinnæ are given enlarged four and a half times at figs. 9*a* and 9*b*, which show their form and nervation. The margin of the pinnules is more or less distinctly crenate, and the appearance is as if the extremities of the veinlets had caused a contraction of the margin of the pinnule as the little crenations are situated between them.

The lateral veinlets are more frequently simple, but sometimes again divide, though in the pinnules enlarged here they were all undivided.

Although the fertile specimen seen at fig. 10, natural size, is too imperfect for detailed description of the sori, it shows that the fertile pinnules have a thick foot-stalk which seems to terminate in a disc-like structure, to whose lower surface the sporangia are attached and hang down like a fringe. A tertiary fertile pinna is enlarged four times at fig. 10*a* to illustrate their appearance. Notwithstanding the imperfect preservation of the fertile specimen I do not think there can be any doubt as to *Sphenopteris communis* Lesqx. belonging to the genus *Crossotheca.*

LESQUEREUX describes the primary rachis of *Crossotheca* (*Sphenopteris*) *communis* as winged, but unfortunately on none of my specimens is the primary rachis distinctly seen.

Crossotheca communis Lesqx. sp. is very closely related to *Cyatheites Beyrichi* Weiss, † though I rather think it is specifically distinct from it. WEISS describes the principal rachis as punctate, a character to which LESQUEREUX does not refer, but on one of the specimens received from Mr LACOE,‡ the primary pinnæ spring from a

* See *ante* pl. xiii, fig. 5.

† "Foss. Flora der jüngst. Steink. u. des Rothl.," Heft 1, p. 70, pl. viii, fig. 1, 1869. See also ZEILLER, "Bassin houil. et perm. de Brive," p. 29, pl. vi, figs. 3, 3A–3D, 1892.

‡ Kidston Collection, No. 1343.

rachis about 1 cm. broad which is distinctly punctate. Weiss makes no mention as to whether the surface of the pinnules of *Cyatheites Beyrichi* were smooth, villous, or papillose.

For my Staffordshire specimens I am indebted to the late Dr W. Hind, and for those from Yorkshire to Mr W. Hemingway.

Distribution.—*Crossotheca communis* Lesqx. sp. is very rare in Britain and has been recorded only from the Westphalian Series.

WESTPHALIAN SERIES.

North Staffordshire Coalfield.

Horizon : Bed below Moss Coal. *Locality :* Lane End, Fenton (Dr W. Hind).

Yorkshire Coalfield.

Horizon : Barnsley Coal. *Localities :* Monckton Main Colliery, near Barnsley (W. Hemingway) ; Woolley Colliery, Darton, near Barnsley (W. Hemingway).

Crossotheca Crepini Zeiller.

Plate LXXXVII, fig. 1, 2 ; text-fig. 27.

1883. *Crossotheca Crepini* Zeiller, *Ann. Sci. Nat.*, 6ᵉ sér., Bot., vol. xvi, p. 181, pl. ix, figs. 1–9.
1886. *Sphenopteris* (*Crossotheca*) *Crepini* Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 112, pl. xiii, figs. 1–3 ; text-fig. 21, p. 33.
1910. *Sphenopteris* (*Crossotheca*) *Crepini* Schmitz in Renier, " Documents pour l'étude paléont.," pl. lxviii.
1913. *Crossotheca Crepini* Bertrand, " *Sphenopteris* du bassin houil. du Nord," *Ann. Soc. géol. du Nord*, vol. xlii, p. 315.
1913. *Crossotheca Crepini* Carpentier, " Contrib. à l'étude du Carbon. du Nord de la France," *Mém. Soc. géol. du Nord*, vol. vii, p. 380, pl. ix, figs. 4, 5.
1914. *Crossotheca Crepini* Kidston, " Fossil Flora South Staffordshire Coalfield," pt. iii, *Trans. Roy. Soc. Edin.*, vol. l, p. 91.
1883. *Sorotheca Crepini* Stur, " Morph. u. Syst. der Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 807 (175) (text-fig. 39 not accurate).
1885. *Sorotheca Crepini* Stur, " Carbon-Flora der Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 275, pl. xxxiii, figs. 1 and 2 ; pl. xxxv, figs. 3, 4 (text-fig. 43, p. 273, not accurate).

Description.—Pteridosperm. Frond tripinnate. Main rachis 4–7 mm. broad, smooth or marked with very fine, irregular striæ. Primary pinnæ alternate or subopposite, springing from the rachis at an angle of 45° to 70°, broadly lanceolate, contracted slightly towards the base, narrowing gradually above their centre and terminating in a point, touching each other laterally ; rachis straight or slightly flexuous, smooth or with irregular, fine, longitudinal striæ. Secondary pinnæ lanceolate or broadly lanceolate, gradually contracting towards the apex, close, free or touching laterally, rachis straight, the larger bearing about twelve pairs of pinnules.

Pinnules alternate, oblong or oblong-lanceolate, slightly oblique to rachis, and having, according to position on the rachis, five to nine decurrent, slightly oblique alternate segments with obtuse apices which are separated by a more or less deep sinus. Nervation immersed and seldom observable, but consists of a thick central vein which gives off oblique, simple veinlets, which may become further divided.

Fertile pinnules of different form from the sterile ones but are borne on the same frond, the upper portion of which, however, remains sterile. The secondary fertile pinnæ have from five to nine oval pinnules 3–5 mm. long and 2 mm. broad, pedicellate, alternate or subopposite, a little depressed at the centre, and bearing on their whole circumference a series of slender exannulate, cylindrical, sharp-pointed sporangia, 1·5 mm. long and 0·3 mm. broad, placed close to each other and which spread outwards or hang down like a fringe.

Remarks.—*Crossotheca Crepini* has only been found in the sterile condition in Britain and on only four occasions. A fragment of a frond is seen at fig. 1, Pl. LXXXVII, natural size, and shows portions of three primary pinnæ, none of which is perfect. The pinnæ slightly overlap at their margins, the rachis is straight and bears many closely placed pairs of lanceolate secondary pinnæ. The pinnules are decurrent, free, and though usually placed somewhat close to each other are occasionally separated by a short distance, especially on the more developed and presumably lower region of the frond. This condition is illustrated in the specimen figured by Père G. Schmitz in Renier (*loc. cit.*). The pinnules on the basal portion of the pinnæ bear three or four pairs of alternate, oblique, obtuse or sub-truncate lobes which are separated by a wide sinus; the upper pinnules have fewer lobes, while those of the apical region are small, have only slight indications of lobes or are entire. A part of the specimen given at fig. 1 is enlarged two times at 1*a*, to show more distinctly the form of the pinnules.

Another fragment of a frond is given, natural size, at fig. 2. The lobes on the pinnules of this example are not so prominent as those on the pinnules of the specimen given at fig. 1.

To illustrate the fructification of *Crossotheca Crepini*, a sorus copied from Zeiller, enlarged five times, is given at text-fig. 27. It shows the oval form of the limb attached to the rachis by its stout footstalk and the surrounding fringe of sporangia. Zeiller thought that the sporangia were arranged in pairs or perhaps in groups of four, but was unable to determine whether they were free or united at the base. They are more probably free as in the other members of the genus. That the organs which surround the fertile pinnules are microsporangia cannot now be doubted, though Stur believed the structure to represent a capsule which, for the dissemination of the spores at maturity, split into a number of segments.

Text-fig. 27.—*Crossotheca Crepini* Zeiller. Fertile pinnule enlarged five times. After Zeiller.

Crossotheca Crepini Zeiller differs from *Crossotheca sagittata* Lesqx. and *Crossotheca Boulayi* Zeiller in the form of its sterile pinnules, which are oblong or lanceolate-oblong with distinctly defined obtuse lobes, whereas in the two other species mentioned above the sterile pinnules are pecopteroid in form with less prominent rounded lobes. The fertile pinnules also differ in form. In *Crossotheca Crepini* they are oval and contract at the base into the foot-stalk, while in *Crossotheca sagittata* and *Crossotheca Boulayi* the fertile pinnules have a hastate base.

Distribution.—*Crossotheca Crepini* Zeiller is restricted to the Westphalian Series. It is rare in Britain and has only been met with at the localities mentioned below.

WESTPHALIAN SERIES.

South Staffordshire Coalfield.

Horizon: Blue Measures, 6 feet above Brooch Coal. *Locality:* Hamstead Colliery, Great Barr, near Birmingham (H. Insley).

Horizon: Roof of Brooch Coal. *Locality:* Grets Green, near Dudley (H. W. Hughes).

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley (W. R. Barker).

South Wales Coalfield.

Horizon: Lower Pentre Seam. *Locality:* Trane Colliery, Gilfach Goch, Glamorganshire (D. Davies).

Crossotheca pinnatifida Gutbier sp.

Plate XC, figs. 1–5; text-fig. 28.

1835. *Neuropteris pinnatifida* Gutbier, " Abdr. u. Verstein. d. Zwickauer Schwarzkohl.," p. 61, pl. viii, figs. 1–3.
1838. *Neuropteris pinnatifida* Presl in Sternberg, " Versuch, " vol. ii, fasc. vii–viii, p. 137.
1843. *Neuropteris pinnatifida* Gutbier in Geinitz, " Gaea von Sachsen," p. 79.
1845. *Neuropteris pinnatifida* Unger, " Synop. plant. foss.," p. 47.
1849. *Neuropteris pinnatifida* Gutbier " Verstein. d. Rothl. in Sachsen," p. 13, pl. v, figs. 1–4.
1850. *Neuropteris pinnatifida* Unger, " Genera et species," p. 83.
1858. *Alethopteris pinnatifida* Geinitz, " Leitpflanzen des Rothl. u. des Zechstein. (Oster-Programm d. königl. polytech. Schule zu Dresden)," p. 13 (*excl. syn.*).
1869. *Asterocarpus pinnatifidus* Weiss, " Foss. Flora d. jüngst. Stk. u. Rothl. in Saar-Rhein-Gebiete," p. 93 (refs. in part).
1869. *Pecopteris* (*Cyath.*) *pinnatifida* Schimper, " Traité de paléont. végét.," vol. i, p. 507 (excl. syn.).
1892. *Pecopteris pinnatifida* Zeiller, " Bassin houil. et perm. de Brive," p. 22, pl. vi, figs. 1, 2.
1893. *Pecopteris* (*Crossotheca ?*) *pinnatifida* Potonié, " Flora d. Rothl. v. Thüringen," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft 9, p. 89, pl. iv, fig. 8 (?); pl. x, fig. 1; pl. xi, fig. 2 (?); pl. xviii, figs. 9, 10.
1901. *Crossotheca pinnatifida* Stefani, " Flore Carb. e Perm. della Toscano," p. 36 (? pl. iv, figs. 3, 4; pl. vii, figs. 1–5).
1843. *Weissites asterocarpoides* Gutbier in Geinitz, " Gaea von Sachsen," p. 84.

Description.—Pteridosperm. Frond tripinnate or quadripinnate, main rachis 1·5 cm. broad. Primary pinnæ broadly lanceolate, rachis straight, striated longitudinally and apiculate. Secondary pinnæ alternate, close, generally touching laterally, narrow-lanceolate, gradually contracting into a sharp point, rachis straight with very fine longitudinal striations. Pinnules alternate, slightly oblique to rachis, varying much in form according to the position of the pinnæ on the frond on which they occur. On the uppermost pinnæ they are oblong, entire, sessile, slightly oblique to rachis, decurrent and more or less united to each other; on secondary pinnæ somewhat farther removed from the apex, the pinnules are oblong, sessile, but contracted slightly at base and decurrent, giving to the rachis a slight wing; on still lower secondary pinnæ the pinnules are oblong, blunt, free, touching each other by their margins, contracted at base and only attached to rachis by the central vein with perhaps a very narrow border of the limb on each side, when they have the appearance of a Neuropteris pinnule; margins frequently slightly sinuous or waved, with a distinct basal auricle or lobe on one or both sides; pinnules on basal secondary pinnæ are narrow, elongated, with blunt apices, and bear 6–8 or more rounded lobes which sometimes are so deeply separated that they take the form of pinnules, and the rachis that bears them assumes the form of a tertiary pinna. Nervation: in free pinnules of Neuropteroid form the central vein divides into two or three dichotomous branchlets a short distance below the blunt apex, and laterally it gives off arcuate veinlets which dichotomize once or twice in their course to the margin of the pinnule. The upper veinlets sometimes dichotomize only once. In the much-lobed pinnules (or tertiary pinnæ) the central vein of each lobe gives off usually simple lateral veinlets which go off at a more acute angle than those of the free Neuropteris-like pinnules.

The fertile pinnules are situated on the basal secondary pinnæ. Pinnule limb reduced to a disc-like, stalked expansion to whose under surface the microsporangia are attached. In young condition the microsporangia bend in towards the centre of the sorus and form a small hemispherical group; at maturity they spread outwards and appear as a fringe to the margin of the pinnule. The sorus attains a diameter of 5 mm.

Remarks.—*Crossotheca pinnatifida* Gutbier sp., which is extremely polymorphic in the form of its sterile pinnules, was originally placed by Gutbier in *Neuropteris*. The pinnules on the middle secondary pinnæ are contracted at the base, have a small point of attachment to the rachis, and possess a great similarity to the pinnules of that genus. This is seen in the enlargement of two pinnules given at fig. 3*a*. The same form of pinnule, however, occurs in other species of *Pecopteris*, and subsequent authors removed Gutbier's plant from *Neuropteris* and placed it in *Pecopteris*, to which genus Gutbier himself points out its very close relationship.* If one considers the sterile condition alone, the whole affinities of the plant are Pecopteroid.

On the uppermost secondary pinnæ the pinnules become confluent, and even at the apex of the secondary pinnæ where the lower pinnules are free and contracted at base the uppermost are usually slightly united to each other. On the pinnæ holding a slightly lower level, the pinnules are somewhat contracted and decurrent

* "Abdr. u. Verstein. d. Zwickauer Schwarzkohl.," p. 62.

and form a narrow wing to the rachis, as seen on the two pinnules which are enlarged two times at fig. 5. On the still lower pinnæ, but not those at the base of the primary pinnæ, the pinnules become more contracted and seem to be united to the rachis by only a small point, where the vein enters from the rachis. In this condition the pinnules assume the form of those of *Neuropteris.* This is shown at fig. 3 and more clearly illustrated at fig. 3*a*, where two pinnules are enlarged three and a half times. These free pinnules have usually a very characteristic basal blunt lobe, sometimes on the proximal margin, more frequently on the distal margin, and often on both sides.

On the specimen seen at fig. 3, which held a higher position on the frond than that given at figs. 1 and 2, the great majority of the pinnules have more or less rounded auricled bases, and are only attached to the rachis by their midrib. In this condition the pinnules have all the appearance of those of *Neuropteris.*

On the upper secondary pinnæ of the example given at fig. 2 the pinnules are also Neuropteroid, but on the lower secondary pinnæ the pinnules first become elongated with sinuous margins, then they quickly (as on the basal pinna seen in the figure) assume the form of tertiary pinnæ with short obtuse pinnules, united to each other for about half their length. At this point the frond might be described as quadripinnate.

The specimen seen at fig. 1 probably comes from a slightly lower level of the frond than that given at fig. 2. The figure is so placed on the plate that its upper end is in the direction to which the arrow points. On the uppermost pinnæ the pinnules are Neuropteroid and narrow-elongate, with straight margins and obtuse apices. The next lower pinna bears narrow, still more elongated growths with fairly well defined lateral lobes, while on the two secondary pinnæ below the last, the elongated structures have assumed the form of tertiary pinnæ, one of which is enlarged at fig. 1*a*, where the prominent lobes can only be regarded as adnate pinnules. Possibly the figure of *Pecopteris pinnatifida* given by Zeiller in his " Bassin houiller et permien de Brive," pl. vi, fig. 2, represents a further stage in the quadripinnate division of the frond.

The nervation is somewhat distant, the lateral veins all dichotomize once, and the two branches sometimes make a second dichotomy, though one of them frequently remains undivided. A short distance below the apex the midrib divides into three dichotomous branches as seen at fig. 3*a*. In the pinnules of the form shown at fig. 1*a* the middle vein of each lobe gives off simple lateral veins which take a more steep course in passing outwards to the margin than those in the Neuropteroid-like pinnules. The rachis of the primary pinnæ is finely but distinctly punctate, though this would be observable only on well-preserved specimens, as the cicatricules are very small.

The fructification was first figured and described by Gutbier in the " Verstein. d. Rothl. in Sachsen," pl. v, figs. 3 and 4, but has more recently been figured and described by Potonié (*loc. cit.*), from whom the following details are derived.

The sori, which are 5 mm. in diameter and have a pedicel 3 mm. long, are situated on the lower secondary pinnæ and in some cases only a few of the pinnules are fertile, the others retaining their normal form, but in other cases the whole of the pinnules on the pinna bear sori as shown by GUTBIER.* The petioles of the fertile pinnules appear as if they had been raised up so that the fertile surface faces obliquely outwards. Whether this has been brought about by natural means or is accidental is difficult to decide on the material before one. At text-fig. 28 the central part of POTONIÉ's fig. 1, pl. x, is reproduced, and shows this feature and the position of the sori on the under surface of the pinnæ. Another fragment of a fertile pinna, also taken from POTONIÉ, is given on Pl. XC, fig. 4. Here the sori are in an immature condition, where the microsporangia are bent inwards and meet in the centre, but at maturity these will spread out and appear as seen at *a* in text-fig. 28. This is

TEXT-FIG. 28.—*Crossotheca pinnatifida* Gutbier sp. Primary pinna with sterile and fertile secondary pinnæ. Natural size. From POTONIÉ. "Flora des Rothliegenden von Thüringen," pl. x, fig. 1.

similar to that observed in the sori of *Crossotheca Hœninghausi* Brongt. sp. and other species of the genus.

The fructification of *Pecopteris pinnatifida* Gutbier sp. agrees therefore in all essential characters with that of *Crossotheca,* in which genus it is included here. That such is its systematic position has already been suggested by ZEILLER and POTONIÉ. POTONIÉ (*loc. cit.*) and STEFANI (*loc. cit.*) have united the *Pecopteris integra* Andrae with *Crossotheca pinnatifida,* but so far as I understand *Crossotheca pinnatifida* the two plants seem to be specifically distinct.

It has also been suggested that the *Callipteridium Aldrichi* Lesqx. should be united with *Pecopteris pinnatifida,* but the nervation of the pinnules as figured and described by LESQUEREUX is essentially distinct from that of *Crossotheca pinnatifida.*

In regard to the proposed union of *Crossotheca æquabilis* Grand 'Eury with

* "Verstein. d. Rothl. in Sachsen," pl. v, fig. 4.

GUTBIER's plant, the sori in the former species have shorter pedicels, are smaller and more closely placed together than in *Crossotheca pinnatifida*, and their arrangement and general appearance are very different.*

Several authors have proposed the union of *Pecopteris Geinitzii* Gutbier † and *Pecopteris fruticosa* Gutbier ‡ with *Crossotheca* (*Pecopteris*) *pinnatifida*, but it has been pointed out by ZEILLER § that these two species have an *Asterotheca* type of fructification and therefore cannot possibly be referred to it.

Distribution. — In Britain, *Crossotheca pinnatifida* Gutbier sp. has only been found in the Radstock Group of the Radstockian Series, where it is rare.

RADSTOCKIAN SERIES.

SOMERSET AND BRISTOL COALFIELD.

Horizon : Radstock Group. *Localities :* Ludlow's Pit, Radstock, Somersetshire; Upper Conygre Pit, Timsbury, Somersetshire; Camerton, Somersetshire.

Crossotheca sagittata Lesquereux sp.

Plate LXXXVII, fig. 3.

1870. *Staphylopteris sagittatus* Lesqx., "Geol. Survey Illinois," vol. iv, p. 407, pl. xiv, figs. 3–5.
1879. *Sorocladus sagittatus* Lesqx., "Coal Flora," vol. i, p. 329, pl. xlviii, figs. 10–10*b*.
1884. *Sorocladus sagittatus* Lesqx., *ibid.*, vol. iii, p. 760, pl. C, figs. 4, 5.
1870. *Pecopteris abbreviata* Lesqx., "Geol. Survey Illinois," vol. iv, p. 403.
1879. *Pecopteris abbreviata* (?) Lesqx., "Coal Flora," vol. i, p. 248, pl. xlvi, figs. 4–6.
1902. *Crossotheca sagittata* Sellards, *Amer. Journ. of Science*, vol. xiv, p. 196, pl. vii, figs. 1–3*c* and 8.
1913. *Crossotheca sagittata* Carpentier, "Contrib. à l'étude du Carbon. du Nord de la France," *Mém. Soc. géol. du Nord*, vol. vii, p. 381, pl. ix, fig. 7.

Description.—Pteridosperm. Frond tripinnate or possibly further divided. Penultimate pinnæ broadly lanceolate, rachis thick, straight. Ultimate pinnæ broadly linear-lanceolate, rachis thick, straight. Pinnules oblique, close, slightly decurrent, and united to each other at the base. Those on lower ultimate pinnæ alternate, oblique, oblong-lanceolate, and bearing about five pairs of rounded lobes, which are separated by a sinus that extends inwards about one-third the width of the pinnule; those on pinnæ holding a higher position have sinuous or feebly lobed

* The following are the references to the species which have been referred to in the above notes :—
1849. *Sphenopteris integra* Andrae in GERMAR, "Verstein. d. Steink. v. Wettin u. Löbejün," p. 67, pl. xxviii, figs. 1–3.
1869. *Pecopteris integra* Schimper, "Traité de paléont. végét.," vol. i, p 530.
1886. *Pecopteris integra* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 211, pl. xxv, fig. 5.
1888. *Pecopteris integra* Zeiller, "Flore foss. terr. houil. de Commentry," pt. 1, p. 160, pl. xvii, fig. 2.
1879. *Callipteridium Aldrichi* Lesqx., "Coal Flora," p. 171, pl. xxxix, figs. 1–3.
1890. *Crossotheca æquabilis* Grand 'Eury, "Géol. et paléont. du bassin houil. du Gard.," p. 271, pl. vi, figs. 21, 22.

† "Verstein. d. Rothl. in Sachsen," p. 16, pl. ii, fig. 10 ; pl. ix, figs. 1–3 ; pl. xi, figs. 5, 6.

‡ *Loc. cit.*, p. 16, pl. v, figs. 8, 9.

§ "Bassin houil. et perm. de Brive," p. 23.

margins, while those on the uppermost ultimate pinnæ are small, oblong, entire, with a blunt apex. The central vein of pinnule is " broad, shallow, and decurrent. The lateral veins curve regularly to the border and fork once, twice, or three times, according to the size of the pinnule." " Some of the veins are heavier than others, giving the venation an irregular appearance." *

Fertile pinnæ of same form as the sterile ones. The whole upper portion (if not the whole) of the penultimate pinnæ may be fertile, though sometimes the apical region bears a few sterile pinnules or pinnæ. The large fertile pinnules are sagittate, though the smaller fertile pinnules are only slightly sagittate. All have a more or less distinct stout foot-stalk. The sorus attains a length of about 1 cm. Sporangia 2·5 mm. to 4 mm. long and 0·50 mm. to 0·75 mm. broad, placed " in a single row around the entire border of the pinnule, free nearly or quite to the base, and are often seen filled with spores." Spores " large, from 0·56 to 0·60 mm., round, and marked at the apex by three distinct radiating lines. The exospore is thick, resistant, brownish, and marked by minute warty thickenings."†

Remarks.—As the small example given in the figure is the only British specimen of *Crossotheca sagittata* that I have seen and only exhibits a fragment of a fertile pinnæ, the description of this species given above has been drawn up from those published by Lesquereux and Sellards, as well as from the examination of specimens of *Crossotheca sagittata* kindly given to me by the late Mr R. D. Lacoe.

Our solitary specimen shows the apical portion of a pinna which terminates in three sterile, oval pinnules, united to each other by their bases. Of the next lower pair of pinnules, that on the left is sterile while that on the right is fertile. The nervation of the sterile pinnules agrees with that shown on one of the specimens of this species received from Mr Lacoe, which has some sterile pinnæ at the apex.‡ The fertile pinnules on our specimen, especially the one on the right side, exhibit the sporangia as a fringe hanging from the limb of the pinnule in a similar manner to that seen at the upper end of the figure given by Lesquereux in the " Coal Flora," vol. iii, pl. c, fig. 5. Although the British specimen is so fragmentary, it agrees perfectly in all its characters with those of *Crossotheca sagittata* Lesqx. sp.

The sterile condition of *Crossotheca sagittata* was described by Lesquereux under the name of *Pecopteris abbreviata* (?) Brongt., but at a later date and after the publication of his " Coal Flora," he prepared a description and figures showing his *Pecopteris abbreviata* (*non* Brongt.) in organic connection with *Crossotheca sagittata* Lesqx. sp., but these have not been published.§

Crossotheca Boulayi Zeiller is closely related to *Crossotheca sagittata* Lesqx. sp., and the relationship of these two to each other will be dealt with when describing the former species.

* Sellards, *loc. cit.*, p. 197.

† Sellards, *loc. cit.*

‡ Kidston Collection, No. 1355.

§ See Sellards, *loc. cit.*, p. 198. Lesquereux had re-named in MS. the plant provisionally referred by him to *Pecopteris abbreviata*, *Percopteris Fontainei*, and one of my specimens received from Mr Lacoe (No. 1353) bears on the original label " *Sorocladus sagittatus* Lesqx. = *Pecopteris Fontainei* " (Lesqx. in MS.).

Distribution.—Very rare, only a single occurrence of *Crossotheca sagittata* has been recorded in Britain.

RADSTOCKIAN SERIES.

SOUTH WALES COALFIELD.

Horizon: Mynyddislwyn Vein, at base of the Series. *Locality:* Gelli-deg Level (Mr RICHARD'S Level) Maes-y-Cwmmer, Monmouthshire (Collection of Geological Survey, London).

Crossotheca Boulayi Zeiller.

Plate XCI, figs. 1–6, 6*a*, 7; text-fig. 29.

1886. *Sphenopteris* (*Crossotheca*) *Boulayi* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 115, pl. iv, figs. 4, 4A–4C.

1913. *Crossotheca Boulayi* Bertrand, "*Sphenopteris* du Nord de la France," *Ann. Soc. géol. du Nord*, vol. xlii, p. 315.

1913. Cf. *Crossotheca Boulayi* Carpentier, "Contrib. à l'étude du Carbon. du Nord de la France," *Mém. Soc. géol. du Nord*, vol. vii, p. 381, pl. ix, fig. 8.

Description.—Pteridosperm. Frond tripinnate, probably quadripinnate in the basal region. Main rachis 5 mm. broad, irregularly striated longitudinally, straight or slightly flexuous. Primary pinnæ alternate, broadly lanceolate with blunt apices, generally touching laterally or slightly overlapping, rachis straight. Secondary pinnæ alternate, oblong or oblong-lanceolate, with blunt apices, usually touching laterally; the basal and larger are about 8 mm. long, rachis straight. Sterile and fertile pinnules dissimilar. Sterile pinnules alternate, close, small, oblong, very obtuse, contracted at base into a broad footstalk (? or sessile), margin entire or crenulate. The thick central vein gives off stout, slightly arcuate, dichotomous, lateral veinlets, in the lower portion of the pinnule, the upper branch usually again divides, but in the upper part of the pinnule no secondary dichotomy of the upper arm of the fork takes place. The secondary pinnæ as traced upwards become smaller, crenate, and quickly assume the form of pinnules, at first with crenate margins but as they decrease in size their margins become entire. Fertile portion restricted to the lower primary pinnæ which are bipinnate, the fertile pinnules occupying the place of the secondary sterile pinnæ. Pinnules of hastate form 1 cm. to 1·20 cm. long and 2 mm. to 3 mm. broad, upper surface with a slight central furrow, linear, terminating in a rounded point. Microsporangia with a narrow central furrow, exposed portion beyond margin of pinnule 2 mm. to 2·50 mm. long, touching each other laterally, very numerous, and occupying the entire circumference of the pinnæ from which they hang like a fringe.

Remarks.—ZEILLER thought that the specimen of *Crossotheca Boulayi* which he figured on his pl. iv, fig. 4, represented part of a frond rather than a portion of a primary pinna, and thus described the species as tripinnate or probably quadripinnate on the lower part of the frond, but whether his specimen is part of a frond or a portion of a primary pinna, must, I think, remain for the present undecided.

Four sterile portions of the frond are given natural size on Pl. XCI, figs. 1–4. The specimens are preserved on an arenaceous shale which frequently does not show a clear outline to the sterile pinnules except as indicated by the terminations of the strong veins. It can, however, be seen at various places on the specimens.

At fig. 1 the upper portion of a frond or primary pinna is seen. The upper primary pinnæ are pinnate. The basal pinnule on the anterior side is larger than the corresponding pinnule on the posterior side. They are obtuse and appear to be slightly contracted at the base. On the second lowest pinna on the left side the anterior basal pinnule is much developed and bears two or three prominent lobes on each side, while on the lowest pinna the basal pinnule on the anterior side is represented by a small secondary pinna which bears three small oval pinnules on each side, the two upper of which are adnate to the broad blunt-pointed terminal lobe.

On the fragment of a pinna given at fig. 2 the pinnules are all oblong, gradually narrowing into an obtuse point, united to the rachis by their whole width, and at their extreme base joined to each other. The midrib is very thick, and the lateral veinlets, which in the great majority of cases only divide once, are also proportionately thick.

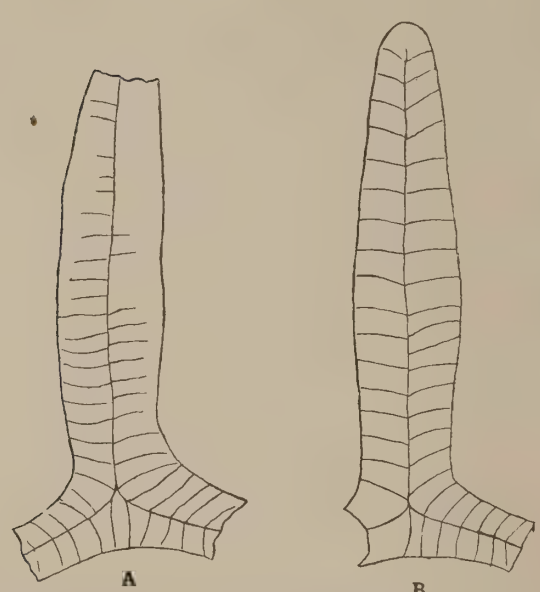
The fragments of pinnæ shown at fig. 3 have more elongated free pinnules, the longer of which have slight crenate margins, and in some cases the lobes have become free and the structure assumes the form of a secondary pinna.

The small specimen seen at fig. 4 is very similar to that seen at fig. 2, which shows the dorsal surface of the pinnules where the veins are raised above the general surface, but at fig. 4 the upper surface is exposed and the veins are seen to be placed in little gutters or furrows, between which the tissue of the limb slightly arches up and gives the pinnules a slightly wrinkled appearance.

In all these variations of form and segmentation of pinnule, the thick central vein and lateral veinlets maintain their characteristic thickness.

Portions of some fertile primary pinnæ, which are given off from a main rachis about 4 mm. broad, are seen at fig. 5 natural size. All the fertile pinnæ on this and other examples seem to be pinnate. Their rachis is from 1 mm. to 1·5 mm. broad, straight, smooth or faintly striated longitudinally. The fertile pinnules are alternate, free, and about 3 mm. to 4 mm. apart. They are about 1 cm. long and have short, stout pedicels. The whole fructification seems to have possessed a rigid type of growth. On this example all the pinnules have been flattened in such a manner that they exhibit a side view, and the microsporangia appear like a fringe to the margin of the slightly curved sori. Some similar but more prominently sickle-shaped sori are seen at fig. 6, natural size, and enlarged two times at fig. 6*a*. Some of these on the latter figure show a portion of the upper surface, but the limb of the pinnule is in no case completely displayed. They exhibit very beautifully, however, the enormous number of microsporangia borne by the sori on each margin of the pinnule, twenty-five to thirty sori being present. They are attached to the lower surface of the pinnule and hang down from underneath the margin. None of the sori to which reference has yet been made has exhibited a hastate base, but it may be present though not recognizable on account of the two cusps having been pressed against each other when the sori were flattened and they are thus seen in side view as at fig. 5. As the cusps also bore sporangia on all sides, each sorus must have had not less than sixty and probably even a greater number of microsporangia.

Three of our specimens showed sori which exhibited the hastate base, but in no case were the cusps completely exhibited, all having lost part of the apex so their full length cannot be determined. Two pinnules exhibiting the imperfect hastate base are seen at fig. 7, enlarged two times. The true outer surface of these pinnules is not preserved. It had been converted into a layer of coaly matter of a very appreciable thickness, but now fallen off. It clearly showed, however, that when the plant was in life the limb of the pinnule must have been of a thick fleshy nature. The pinnules as now preserved at fig. 7 show a convex surface with a median furrow from which depart on each side narrow thread-like furrows, most usually those on one side being in line with those on the other side of the median furrow, but this is not universally the case. (Text-fig. 29.) When the carbonaceous matter is still preserved on the upper surface of the pinnule it seems to show the true outer surface of the limb, and in some cases the two rows of lateral transverse lines can be seen to extend from the middle to the margin of the pinnule, where they terminate in a line with the margins of the microsporangia. In addition to these lines, and placed between them, are two parallel rows of very small protuberances which mark the point of attachment of the sporangia on the under side of the pinnule.



TEXT-FIG. 29.—*Crossotheca Boulayi* Zeiller. Two fertile pinnules enlarged 6 times. Explanation in text. *Locality*: Cambrian Collieries, Clydach Vale, Rhondda. Kidston Collection, A, No. 4156, B, No. 4155.

ZEILLER refers to the two rows of small elevations on each side of the median furrow on the upper surface of the fertile pinnule, and further notes that on his specimen each sporangium had usually a median furrow which might indicate the union of two sporangia or perhaps the line of the dehiscence.

The specimens described above agree in all respects with *Crossotheca Boulayi* Zeiller, except that the fertile pinnules show a sagittate or hastate base. I therefore sent photographs of my specimens to the late Prof. ZEILLER and asked him if he had observed any trace of a hastate base on any of his fertile specimens of *Crossotheca Boulayi*. In reply he said, " However, on freeing the base of one of the fertile pinnules from one of the specimens which I have figured, I exposed what might be the beginning of the prolongation of the limb which could represent the base of one of the lobes, but one cannot possibly affirm that it is so. In any case the hastate form of these fertile primary (or perhaps it was only the most developed among them that possessed these basal lobes) appears to me to make the identity with *Sorocladus sagittatus* Lesqx., of the fig. 5, pl. c. of the Coal Flora, possible." More recently Canon Carpentier has found a specimen of *Crossotheca* which he refers to *Crossotheca Boulayi*, but with doubt on account of the fertile pinnules having a hastate base (*loc. cit.*).

It would appear, then, that there can be no doubt as to our specimens belonging to *Crossotheca Boulayi*, but the question remains as to the relationship of that species to *Crossotheca sagittata* Lesqx. sp.

The sterile condition of both species appears to be very similar. The fertile pinnules, however, seem to be absolutely different. On two specimens of *Crossotheca sagittata* received from the late Mr Lacoe,* which are two halves of one nodule, the fertile pinnule is 7 mm. long, but their usual size on this specimen is only 5 mm. to 6 mm. long and their width 2 mm. to 3 mm. immediately above where the cusps go off, whereas the fertile pinnules of *Crossotheca Boulayi* are from 1 cm. to 1·20 cm. long and their width immediately above where the cusps go off is 2 mm. wide. Further, the central and larger lobe of *Crossotheca sagittata* is widest at the base and gradually narrows to its blunt apex, whereas the same portion of the fertile pinnule of *Crossotheca Boulayi* is slightly contracted at its base and its widest part is about its centre (text-fig. 29, a, b.) It should, however, be mentioned that the fertile pinnules seen on the specimen illustrated by Lesquereux in his " Coal Flora," vol. iii, fig. 4, pl. c. are larger than those on my specimens from Mazon Creek, but even in this latter figure of *Crossotheca sagittata* they are shorter and broader and are in fact deltoid in outline and quite dissimilar from those of *Crossotheca Boulayi*. On the other hand, the fertile pinnules seen on Lesquereux's fig. 4 of the same plate agree with those in size on the specimens received from Mr Lacoe. The two species, therefore, appear to me to be specifically distinct.

Distribution.—Crossotheca Boulayi Zeiller is very rare, but has been recorded from both the Staffordian Series and the Westphalian Series in South Wales.

STAFFORDIAN SERIES.

South Wales Coalfield.

Horizon : No. 2 Rhondda Seam towards base of the Series. Blackband Group. *Localities :* Cambrian Colliery, Clydach Vale, Glamorganshire (D. Davies) ; Dinas Main Level, Gilfach Goch, Glamorganshire (D. Davies) ; Standard Colliery, Ynyshir, Rhondda Valley, Glamorganshire (R. Weed).

* Kidston Collection, Nos. 1353, 1354.

WESTPHALIAN SERIES.

Horizon: Five-foot Seam (=Seven-foot Seam of Clydach Vale). *Locality:* Britannic Collieries, Gilfach Goch, Glamorganshire (D. DAVIES).

Genus **Urnatopteris** Kidston.

1884. *Urnatopteris* Kidston, *Quart. Journ. Geol. Soc.*, vol. xl, p. 594.
1888. *Urnatopteris* Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 33.
1899. *Urnatopteris* Potonié, " Lehrb. d. Pflanzenpal." p. 93.
1900. *Urnatopteris* Zeiller, " Éléments de paléobot.," p. 61.

Description.—Barren and fertile fronds dissimilar. Sporangia alternate and arranged on the rachis in two opposite rows, oval or urceolate, exannulate, with an apical pore for the dissemination of the spores. Fertile fronds entirely deprived of foliage pinnules.

Remarks.—The sporangia are very similar in form and structure to those of *Danœa*, but are free and not united to each other to form a synangium as in that genus (Pl. LXXXIII, figs. 5, 5*a*). Where referring to the fructification of *Urnatopteris tenella*, in 1883, the late Prof. WILLIAMSON said, " This form of sporangium is identical in all essential features with that of the recent *Danœa* and the fossil *Danœopsis*, in which, also, each series consists of two rows of sporangia, arranged in alternating order " . . . " This combination of a Sphenopterid frond with the sporangia of a *Danœa* is wholly unknown at the present day." The genus was therefore referred to the Marattiaceæ. At that time, however, the very important class of Pteridosperms had not been recognized, but the discovery of this group has necessitated an alteration in the views then held on the affinities of a large number of Carboniferous plants which were then supposed to be ferns.

In the light of these more recent discoveries, it appears improbable that *Urnatopteris* has any affinity with the Marattiaceæ but is much more probably a Pteridosperm, and to that group I would provisionally refer the genus.

Distribution.—The genus occurs in the Staffordian, Westphalian, and Lanarkian Series, but from the Staffordian Series only a single specimen has been recorded.

Urnatopteris tenella Brongniart sp.

Plate LXXXIII, figs. 1, 1*a*, 2, 2*a*, 3, 4, 5, 5*a*; Plate LXXXIV, figs. 1–3; text-fig. 30.

1829. *Sphenopteris tenella* Brongt., " Hist. des végét. foss.," p. 186, pl. xlix, fig. 1.
1833. *Sphenopteris tenella* Sternb., " Versuch," fasc. v–vi, p. 60.
1836. *Cheilanthites tenellus* Göpp., " Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 240.
1882. *Eusphenopteris tenella* Kidston, *Proc. Roy. Phys. Soc. Edin.*, vol. vii, p. 129, pl. i, figs. 1–6.
1882. *Eusphenopteris tenella* Kidston, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. x, p. 7, pl. i, figs. 1–6.

1884. *Urnatopteris tenella* Kidston, *Quart. Journ. Geol. Soc.*, vol. xl, p. 594.
1888. *Urnatopteris tenella* Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 33, fig. 20.
1899. *Urnatopteris tenella* Potonié, " Lehrb. d. Pflanzenpal.;" p. 93, fig. 68.
1899. *Sphenopteris* (*Urnatopteris*) *tenella* Zeiller, " Flore foss. bassin houil. d'Héraclée," (*Mém. Soc. géol. France, Paléont.*, xxi), p. 13, pl. ii, figs. 11, 11A.
1900. *Urnatopteris tenella* Zeiller, " Éléments de paléobot.," p. 62, fig. 30.
1901. *Urnatopteris tenella* Kidston, " Flora of Carboniferous Period," *Proc. Yorks. Geol. and Polytech. Soc.*, vol. xiv, pt. 2, pp. 193, 213, pl. xxix, figs. 1–3.
1904. *Urnatopteris tenella* Arber, " Flora Culm Measures of North-West Devon," *Phil. Trans. Roy. Soc. London*, ser. B, vol. 197, p. 306, pl. xix, fig. 6.
1913. Cf. *Urnatopteris tenella* Depape and Carpentier, " *Urnatopteris*, etc., dans le Westphalien du Nord de la France," *Ann. Soc. géol. du Nord*, vol. xlii, p. 297, pl. xii, figs. 4–9, text-fig. 2.
1913. *Sphenopteris* (*Urnatopteris*) *tenella* Gothan, " Steinkohlenflanzen in der Dortmunder Gegend," *Verhandl. naturhist. Vereins preuss. Rheinl. u. Westph.*, 69 Jahrgang, p. 244, pl. iv (syn. in part).
1877. *Sphenopteris* Lebour, " Illustr. of Fossil Plants," p. 79, pl. xxxix.
1883. *Sphenopteris lanceolata* Williamson (*non* Gutbier, *non* Phillips), *Proc. Roy. Inst. Great Brit.*, vol. x, pt. 2, p. 225, figs. 6*a*, 6*b*.

Description.—Probably a pteridosperm. Sterile and fertile fronds dissimilar. Sterile frond tripinnate or quadripinnate. Penultimate pinnæ alternate, lanceolate, directed forwards, rachis subflexuous ; ultimate pinnæ oblique to rachis, alternate, broadly lanceolate or subdeltoid, rachis straight with a narrow wing, the larger bearing five or six pairs of pinnules. Pinnules oblique to rachis, alternate, subrhomboidal or lanceolate, lowest divided into 5–6 more or less blunt-pointed, linear lobes, of which the lower lobes are sometimes bifid or trifid ; middle pinnules with 3–4 simple, linear, blunt-pointed lobes ; terminal pinnules reduced to an undivided blunt segment. A middle vein sends off a veinlet into each tooth or segment.

Fertile frond with a naked petiole, broadly lanceolate or subdeltoid, tripinnate. Limb of pinnule entirely suppressed. Microsporangia, very numerous and closely placed together, alternate, oval or urceolate, attached to the rachis in two opposite rows by their contracted bases and dehiscing by a terminal pore. They are about 1·50 mm. long and 1 mm. broad. Microspores very numerous, circular, with smooth outer surface and a triradiate ridge, and have a diameter of 60–67 μ for the larger spores and for the smaller 41–44 μ.

Remarks.—Fragments of some penultimate pinnæ are shown at fig. 1, Pl. LXXXIII, natural size, and one of them is enlarged two times at fig. 1*a*. This figure illustrates the most frequent and typical form of the plant as figured by Brongniart, and shows very distinctly the form of the pinnules. The basal pinnule on the anterior side is larger than that on the posterior side. The latter has usually simple segments while on the former the lower segments are sometimes trifid or bifid. The segments contract at the apex and end in a blunt point. The uppermost pinnules on the lower ultimate pinnæ and those on the upper ultimate pinnæ are less divided and have simple segments while the terminal pinnules are reduced to a simple tooth or segment.

Fig. 2 shows a not infrequent form of *Urnatopteris tenella* on which the pinnæ and pinnules are closer and the segments of the pinnules are usually all simple. This specimen is enlarged two times at fig. 2*a* where the form and segmentation of the pinnules are distinctly seen. This example more probably shows the termination of frond, than part of a primary pinna.

A very good figure of *Urnatopteris tenella* appears in LEBOUR's "Illustrations of Fossil Plants," pl. xxxix, and gives an excellent idea of the appearance of the fronds. These probably attained to a fair size, for I have seen a pinna 17·50 cm. long, given off from a rachis 3 mm. broad.

What is regarded as an almost complete fertile frond is given natural size on Pl. LXXXIV, fig. 1, but on account of the dark colour of the matrix on which it occurs the specimen does not show very prominently in the figure. Its apex is broken off but the greater portion of the frond is preserved. The pinnæ-bearing portion is supported on a naked petiole about 4 cm. long, and it is the presence of this naked petiole which has led me to believe that the fertile condition was restricted to specially developed fronds of much smaller size than the sterile ones. The microsporangia-bearing fragments which lie at the side of the petiole in this figure do not belong to it and their position is accidental. The upper portion is formed of crowded fertile pinnæ entirely deprived of foliage organs, which overlap each other so densely that the pinnæ are difficult to distinguish individually, though the frond can be seen to be tripinnate. This dense mode of development of the fertile fronds is a common occurrence. A sketch of this specimen is given at text-fig. 30, to show more clearly its general appearance. Another specimen showing the upper portion of a fertile frond is given at fig. 3, Pl. LXXXIII. Here the alternate pinnæ do not overlap and form such a dense mass of sporangia as that seen at fig. 1, Pl. LXXXIV. This dense and more lax condition of the fertile fronds seems to correspond to the two types of sterile specimens given on Pl. LXXXIII, figs. 1 and 2.

TEXT-FIG. 30.—*Urnatopteris tenella* Brongniart sp. An almost complete fertile frond. Natural size.

A third portion of a fertile frond is seen enlarged about two times at fig. 4, Pl. LXXXIII. This shows the alternate position of the fertile pinnæ.

A few of the sporangia, enlarged eleven times, are given at fig. 5, Pl. LXXXIII. They are oval, alternate, placed close together, and have a small circular pore at the apex. Four of these sporangia are enlarged thirty-three times at fig. 5*a* to show the narrow elongated cells which form the sporangial wall and the small terminal pore through which the spores escaped at maturity.

A sporangium taken from the specimen illustrated at fig. 4, Pl. LXXXIII, was macerated and the spore-contents are seen enlarged fifty times at fig. 2, Pl. LXXXIV.

The spores are very numerous, and some enlarged about two hundred and seventy-five times are given at fig. 3 of the same plate. They are circular, and have a smooth outer surface which shows a triradiate ridge. The great majority of the spores measure about 60–67 μ in diameter, but mixed with them are a few of smaller size, which only measure 41–44 μ (*a*, fig. 3). These may best be regarded as abortive or imperfectly developed spores and probably have no reference to heterospory.

Urnatopteris herbacea Boulay sp. is closely related to *Urnatopteris tenella*, both in the form of the sterile fronds and pinnules as well as in its fructification, but in the former species the pinnæ are more lanceolate, the pinnules are less deeply segmented, the teeth shorter and more closely placed to each other, and the pinnules have a more solid build.

MM. les Abbés Depape and Carpentier have described certain specimens from the Mines of Anzin (Nord), which they refer to *Urnatopteris tenella*,* but if the fertile specimens belong to the sterile plant given at their fig. 4, pl. xii, an assumption there is every reason to believe, then, I think, their specimens are rather to be referred to *Urnatopteris herbacea* Boulay sp. than to *Urnatopteris tenella* Brongt. sp.

At one time I believed that the figure of *Sphenopteris multifida* L. and H. was an imperfect illustration of *Urnatopteris tenella* Brongt. sp., but I now keep them separate as I do not think their relationship to each other can be satisfactorily determined without an examination of the type of *Sphenopteris multifida*, which appears to be lost.†

I also exclude from the synonymy of *Urnatopteris tenella* the references to *Sphenopteris delicatula* given in my paper of 1884.‡

As the systematic position of the genus *Urnatopteris* has already been discussed, it is unnecessary to deal here with the affinities of *Urnatopteris tenella* Brongt. sp.

Distribution.—Although *Urnatopteris tenella* occurs both in the Westphalian Series and the Lanarkian Series, it appears to have a somewhat local distribution. It is more plentiful in the latter series, but is nowhere a very common species though recorded from a number of localities.

WESTPHALIAN SERIES.

Northumberland and Durham Coalfield.

Horizon: High Main Seam. *Locality:* Gosforth, Northumberland (Hancock Museum, Newcastle-on-Tyne).

Horizon: Bensham Seam. *Locality:* Jarrow Colliery, Jarrow, Durham (Hancock Museum, Newcastle-on-Tyne).

Horizon: Either from Stone Coal or Under Five-quarter Coal. *Locality:* Stargate Colliery, Ryton, Durham (W. Eltringham).

Horizon: Townley Seam. *Locality:* Spen Colliery, 3 miles south of Ryton, Durham (W. Eltringham).

* *Ann. Soc. géol. du Nord*, vol. xlii, p. 297, pl. xii, figs. 4–9, 1913.

† See *ante*, p. 104.

‡ *Quart. Journ. Geol. Soc.*, vol. xl, p. 594.

Yorkshire Coalfield.

Horizon: Shales below Better Bed Coal. *Locality:* Quarry at Brickwork, Seymour St., Bradford (M. A. Johnstone).

Horizon: 374 feet above Barnsley Coal. *Locality:* Bentley Colliery, $2\frac{1}{2}$ miles north of Doncaster (H. Culpin).

Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley (W. Hemingway).

"Mines of Yorkshire" (Dr Taylor). Brongniart (type of Species.)

LANARKIAN SERIES.

Ayrshire Coalfield.

Horizon: Major Coal. *Locality:* Hillhead Pit, Kilmarnock (A. Sinclair).

Horizon: Shale above Stranger Coal. *Locality:* Grange Colliery, Kilmarnock.

Clackmannan Coalfield.

Horizon: Bed between Five-foot Coal and Three-foot Splint Coal. *Locality:* Devon Pit, at Old Devon Ironworks, 1 mile south-west of Tillicoultry.

Horizon: Lower Five-foot Coal. *Locality:* Devon Pit, at Old Devon Ironworks, 1 mile south-west of Tillicoultry.

Lanarkshire Coalfield.

Horizon: 8 feet above Kiltongue Coal. *Locality:* Rosehall Pit No. 14, near Coatbridge (Collection of Geological Survey, Edinburgh).

Horizon: Kiltongue Coal. *Localities:* Baillieston (P. Jack); Calderbank, 2 miles south of Airdrie (R. Dunlop); Ellismuir, near Baillieston; Cairnhill, near Airdrie (R. Dunlop); Howlitness, near Airdrie (R. Dunlop); Rawyards Pit, Airdrie.

Horizon: Lower Drumgray Coal. *Locality:* Howlitness, near Airdrie (R. Dunlop).

Horizon: Above Virgin Coal. *Locality:* Lochwood Colliery, No. 3 Pit, Dungeon Hill, Easterhouse.

Horizon: Pavement of Virtuewell Coal. *Locality:* Pit at Heatheryknowe House, 2 miles west of Coatbridge (Collection of Geological Survey, Edinburgh).

Horizon: ? *Localities:* Scrawhill Colliery, near Airdrie; Bartonshill Pit, Bargeddie, 1 mile west of Coatbridge.

Midlothian Coalfield.

Horizon: ? *Locality:* River South Esk, left bank at point south-west of Newmills Bridge and west of Brewlands, Dalkeith (Collection of Geological Survey, Edinburgh).

Stirlingshire Coalfield.

Horizon: Main Coal. *Locality:* No. 13 Callendar Pit, $\frac{1}{4}$ mile S.S.E. of the Glen, $1\frac{1}{3}$ miles south of Falkirk.

Urnatopteris herbacea Boulay sp.

Plate LXXXIV, figs. 4, 5, 5*a*.

1876. *Sphenopteris herbacea* Boulay, " Terr. houil. du Nord de la France," p. 27, pl. i, fig. 5.
1883. *Sorotheca herbacea* Stur, " Morph. u. Syst. d. Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien,* Band lxxxviii, Abth. 1, p. 810 (178).
1885. *Sorotheca herbacea* Stur, " Carbon-Flora der Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.,* Band xi, p. 279, pl. xxxiv, figs. 4–8.
1886. *Sphenopteris* (*Hymenophyllites*) *herbacea* Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 106, pl. vi, fig. 4 ; pl. vii, figs. 3, 4.
1919. *Urnatopteris herbacea* Carpentier, *Comptes rendus Acad. Sci. Paris,* vol. 159, pp. 511, 512.

Description.—Frond tripinnate or quadripinnate on lower portion of primary pinnæ, oval or oval-lanceolate, 25–30 cm. long and about 10 cm. broad. Primary pinnæ alternate, touching each other laterally, attaining a length of 5–6 cm., elongate-triangular, gradually decreasing in width towards the sharp-pointed apex ; secondary pinnæ narrow triangular, gradually contracting to a point, attaining a length of 7–15 mm. and bearing 7–12 or more pairs of alternate pinnules. Pinnules small, directed forwards, narrow-oblong, decurrent, united at the base to each other, those on lower portion of pinna with 3–5 more or less deeply separated lobes with rounded apices ; upper pinnules with frequently 2–3 blunt-pointed teeth ; uppermost pinnules simple with rounded points. The central straight or slightly flexuous vein gives off alternate oblique lateral veinlets, one of which enters each lobe or tooth of the pinnule.

Fertile pinnules reduced, sometimes linear, microsporangia oval, subpyriform, and some appear as slightly disymmetric, from 0·8 mm. to 1·2 mm. long and attached to the lobes by their pointed base. Their upper extremity has a circular depression which would indicate a poricidal dehiscence ; the surface of their walls is ornamented with a net-like reticulation of elongated cells without trace of any line of dehiscence or annulus.

Remarks.—The only British specimen of *Urnatopteris herbacea* which I have seen is the small imperfect example given on Pl. LXXXIV, fig. 4, of which some ultimate pinnæ, reduced almost to the form of pinnules, are enlarged two times at fig. 5, and to show their form more clearly an outline sketch of part of one of these is given at fig. 5*a*, enlarged seven times. Our small fragment is probably from the upper portion of a pinna as only the lowest pinnule shows any lobes, and these are confined to its upper part. The upper pinnules are entire and all are united to each other by their bases. This specimen, though it gives a very imperfect idea of the appearance of *Urnatopteris herbacea,* is a sufficient voucher for the occurrence of the plant in Britain, but I have been dependent on foreign examples for the description given here. Good figures are seen in the works of Stur and Zeiller.

The fructification has been described by Zeiller and Carpentier, but the material examined by the former was badly preserved, while that described by Carpentier seems to have been in an excellent state of preservation. The description of the fertile condition given above is therefore taken from the later investigator.

Urnatopteris herbacea Boulay sp. is closely related to *Urnatopteris tenella* Brongt. sp., but is a larger plant, and has a more robust general appearance than the latter species.

STAFFORDIAN SERIES.

Kent Coalfield.

ETRURIA MARL GROUP. (?)

Horizon: At depth of 1768 feet. *Locality:* Tower Brickworks, Folkestone (Collection of Geological Survey, London).

Genus **Sphyropteris** Stur.

1883. *Sphyropteris* Stur, "Morphologie und Systematik der Culm- und Carbonfarne," p. 23, *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 655.
1885. *Sphyropteris* Stur, "Carbon-Flora der Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 16.
1888. *Sphyropteris* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 31.
1889. *Sphyropteris* Kidston, "Fossil Plants in the Ravenhead Collection," *Trans. Roy. Soc. Edin.*, vol. xxxv, p. 402.
1900. *Sphyropteris* Zeiller, "Éléments de paléobot.," p. 57.

Description.—Sporangia free, exannulate, hemispherical, sessile, and dehiscing by an apical pore, borne on oblique ridges on a narrow expansion, 2–4 mm. long and 0·50 to 1 mm. broad, situated at the extremity of the pinnæ and pinnules placed at a right angle to them, and supported on a stalk-like structure formed by an extension of the rachis of the pinnæ or mid-vein of the pinnules.

Remarks.—This remarkable fructification has very much the appearance of a hammer attached to its handle (Pl. LXXXIV, fig. 6, 6*a*–*c*).

The hemispherical sporangia are attached by a very wide base to the oblique ridges (Pl. LXXXIV, fig. 6*c*). This character has been observed on both species described below. The sporangial walls are formed of elongated cells which radiate from the terminal pore by means of which dehiscence took place (Pl. LXXXIV, fig. 6*d*).

The genus *Sphyropteris*, like that of *Urnatopteris*, has in the past been referred to the Marattiaceæ. Viewed, however, in the light of more recent discoveries, it would appear more probable that the sporangial organs of *Sphyropteris* are the microsporangia of a pteridosperm rather than the sporangia of a fern. At the present time it does not seem possible to determine satisfactorily the systematic position of the genus.

Distribution.—The genus *Sphyropteris* is only known to occur in the Westphalian Series.

Sphyropteris obliqua Marrat sp.

Plate LXXXIV, figs. 6, 6*a*–6*d*, 7.

1872. *Sphenopteris obliqua* Marrat in Higgins, *Proc. Liverpool Geol. Soc.*, Session 13, 1871–72, p. 99, pl. ix, fig. 3.
1889. *Sphyropteris obliqua* Kidston, " Fossil Plants in the Ravenhead Collection," *Trans. Roy. Soc. Edin.*, vol. xxxv, p. 402, pl. i, figs. 3, 3*a*–3*d*.
1891. *Sphyropteris obliqua* Kidston, " On the Fructification, etc., of Carboniferous Ferns," *Trans. Geol. Soc. Glasgow*, vol. ix. p. 28, pl. ii, fig. 29.
1883. *Sphyropteris Crepini* Stur, " Morph. u. Syst. d. Culm- u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 656 (24), fig. 6*c*.
1885. *Sphyropteris Crepini* Stur, " Carbon-Flora der Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 18, pl. xxxix, figs. 1, 1*a*, text-fig. 6*c*, p. 16.
1888. *Sphyropteris Crepini* Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 31, fig. 17.
1899. *Sphyropteris Crepini* Potonié, " Lehrb. d. Pflanzenpal.," p. 93, fig. 65B.
1900. *Sphyropteris Crepini* Zeiller, " Éléments de paléobot.," p. 58, fig. 23.

Description.—Frond quadripinnate, rachis punctate. Primary pinnæ alternate, lanceolate, touching or slightly overlapping, rachis straight. Secondary pinnæ broadly lanceolate, usually not touching, rachis straight or subflexuous, winged. Tertiary sterile pinnæ alternate, lanceolate, gradually tapering to a sharp point, rachis straight or subflexuous with a narrow wing and bearing ten or more pairs of alternate pinnules. Tertiary fertile pinnæ, oblong or oblong-lanceolate and shorter than the sterile pinnæ. Sterile pinnules small, the larger 2 mm. to 2·50 mm. long, broadly oval, truncate, the basal and larger ones having four lateral lobes and a terminal lobe; lobes usually obtusely truncate or emarginate, the uppermost segments sometimes pointed, separated by a sinus with rounded base which extends inwards about a quarter the width of the pinnule. The central vein sends off a veinlet to each lobe where it usually bifurcates, one branch going to each corner of the segment. Fertile pinnules with fewer lobes or entire, occasionally somewhat expanded; from the apex a small stalk-like structure extends and bears at right angles to itself a narrow hammerhead-like expansion from 2·50 mm. to 5 mm. long, on whose surface are five or more oblique ridges which each bear two or three sporangia. Sporangia hemispherical, close, free, sessile, with a terminal pore. Sporangial wall formed of fusiform cells.

Remarks.—A fragment of a sterile secondary pinna is given at fig. 7, Pl. LXXXIV. It shows the narrow lanceolate form of the pinnæ. At fig. 6 a small fertile specimen is seen natural size, and a tertiary pinna from this example is given at fig. 6*a* enlarged three and a half times, and the same pinna is further enlarged at fig. 6*b* to show more distinctly the form of the pinnules. They are broadly oval, and the lower have four or five lobes while those holding a position above them have a smaller number.

The fertile pinnæ are shorter and of a more oblong form than the sterile ones and usually terminate in a fertile, stalked, hammer-like expansion. The small stalk is evidently a prolongation of the rachis (fig. 6*a*). Some of the pinnules also bear similar fertile apical expansions, but in their case the pedicel is an extension of the midrib of the pinnule.

The exposed portion of the sporangia is hemispherical, but their basal portions might have been more or less immersed in the tissue of the ridge on which they sit. This, however, cannot be determined from the material before us. A sporangium is enlarged fifty-three times at fig. 6*d* to show the terminal pore, the form of the cells of the sporangial wall, and the wide base by which it is attached to the ridge.

Sphyropteris Crepini Stur is evidently specifically identical with *Sphyropteris obliqua*, but probably MARRAT's species was unknown to STUR. I can find no character by which it is possible to distinguish them.

The sterile condition of *Sphyropteris obliqua* has a slight similarity to the sterile condition of *Oligocarpia Brongniarti* Stur, but is distinguished by its shorter and more oval pinnules, which have a squat appearance. The fructification of the two plants is essentially distinct.

The example given on Pl. LXXXIV, fig. 6, shows the type specimen of *Sphyropteris obliqua* Marrat sp., which is preserved in the Brown Free Library and Museum, Liverpool.

Distribution.—Sphyropteris obliqua Marrat sp. is rare and has only been recorded from the Westphalian Series.

WESTPHALIAN SERIES.

LANCASHIRE COALFIELD.

Horizon: Brassy Mine. *Locality:* Linnyshaw Pit, Worsley.

Horizon: Shales associated with Ravenhead Coal. *Locality:* Ravenhead, near St Helens (Brown Free Library and Museum, Liverpool).

SOUTH STAFFORDSHIRE COALFIELD.

Horizon: Roof of Fireclay Coal. *Locality:* Doulton's Clay Pit, Netherton, near Dudley (H. W. HUGHES).

Horizon: Ten-foot Ironstone Measures. *Locality:* Clayscroft openwork, Coseley, near Dudley (H. W. HUGHES).

Horizon: Roof of New Mine Coal. *Locality:* Mount Pleasant, Brierley Hill (H. W. HUGHES).

YORKSHIRE COALFIELD.

Horizon: Roof of Old Hards Coal. *Locality:* Hartley Bank Pit, Horbury (Sedgwick Museum, Cambridge).

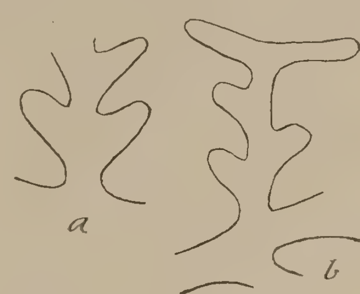
Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley (W. HEMINGWAY).

Sphyropteris *cf.* tomentosa Stur.

Plate LXXXIV, fig. 8, 9 ; text-fig. 31.

1885. *Sphyropteris tomentosa* Stur, " Carbon-Flora der Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 21, pl. xxxix, figs. 2, 2*a*, text-fig. 6*a*, 6*b*, p. 16.

Remarks.—A small fertile specimen of a *Sphyropteris* is given natural size on Pl. LXXXIV, fig. 8, and enlarged two times at fig. 9. The pinnules are almost all fertile and only a few sterile ones occur on the small slab. Both are attached obliquely to the rachis, are subalternate or alternate, have 3–4 blunt-pointed segments, and their surface has a roughened appearance which may best be described as papillose. The lower part of a sterile pinnule is enlarged at text-fig. 31*a*. The segments on the fertile pinnules are slightly smaller but of the same form (text-fig. 31*b*). The fertile expansion at their apex varies in length from 2 mm. to 3·25 mm. and is about 0·5 mm. broad. The sporangia are arranged in slightly distant oblique rows. On the same small slab a fragment of a bipinnate pinna is attached to an apiculate rachis rather over 1 mm. broad.



Text-fig. 31.—*Sphyropteris* cf. *tomentosa* Stur. *a*, portion of sterile pinnule showing form of lobes ; *b*, fertile pinnule. Both enlarged.

From the description of our specimen given above it is seen that it has many characters agreeing with those of *Sphyropteris tomentosa* Stur. The surface of the pinnules cannot, however, be described as tomentose as in that species, but have a roughened papillose appearance. In Stur's species there is also little difference in the form of the fertile and sterile pinnules ; the rachis of our plant is also apiculate.

The fertile expansion on *Sphyropteris tomentosa* is 4 mm. long and 1 mm. broad. On the British specimen it is slightly shorter and only half the width.

The most of these differences are too unimportant for the separation of a species, but the absence of a tomentose surface to the pinnules of our example makes one hesitate to definitely identify the British specimen with *Sphyropteris tomentosa* Stur. It is therefore only provisionally referred to that species.

My thanks are due to Mr R. D. Vernon for the specimen figured on the plate.

Distribution.—Very rare, and only known from a single British locality.

WESTPHALIAN SERIES.

Warwickshire Coalfield.

Horizon : Seven-foot Coal. *Locality :* Chilvers Coton Clay Pit, Heath End, Nuneaton (R. D. Vernon).

Genus **Myriotheca** Zeiller.

1883. *Myriotheca* Zeiller, *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, p. 186.
1888. *Myriotheca* Zeiller, " Flore foss. bassin houil. de Valenciennes," pp. 32, 140, text-fig. 19.

Description.—Sporangia free, ovoid, sessile, exannulate, very numerous, and placed beside each other without order, and covering the entire inferior surface of the pinnule.

Remarks.—On the specimen of *Myriotheca* described by Zeiller the sporangia shed their spores by means of a longitudinal cleft. This, one could scarcely expect to observe on our specimens, as they have not attained maturity and still retain their spores. There is little doubt, however, that they dehisced in a similar manner.

It is very probable that the fossils placed in *Myriotheca* are the microsporangia of Pteridosperms.

Distribution.—The genus has only been recorded from the Westphalian Series.

Myriotheca anglica Kidston n. sp.

Plate LXXVI, figs. 1, 2, 2*a*, 3–6.

Description.—Frond at least tripinnate. Rachis of penultimate pinnæ straight, sparsely punctate, 1·5 mm. or more broad. Ultimate pinnæ alternate, free or touching laterally, departing from parent rachis at almost a right angle, linear, tapering on upper portion to a sharp point, rachis straight, punctate, and bearing about seventeen pairs of pinnules on an ultimate pinna about 4 cm. long. Pinnules alternate, oblong, the larger about 4 mm. long, free, springing from the rachis at almost a right angle, attached by a broad base, and the whole lower surface is covered with sporangia. Sporangia free, sessile, exannulate, oval, rounded at base, and slightly pointed at apex, about 0·70–75 mm. long and 0·50 mm. broad, cells of sporangial wall fusiform, about three times as long as broad. Spores large, very numerous, with smooth surface and a triradiate ridge. The majority are 70 μ to 82 μ in diameter, but mixed with them are a few only 50 μ in diameter. Sterile condition unknown.

Remarks.—Two fertile specimens of *Myriotheca anglica* are given natural size on Pl. LXXVI, figs. 1 and 2. That at fig. 2 gives a better idea of the form of the pinnules and general growth of the plant than that seen at fig. 1, but the sporangia are not well preserved, while on that given at fig. 2 the preservation of the sporangia is very good. The oblong pinnules seem to have had a broad attachment to the rachis, but whether attached by the whole width of the base or that the base was slightly contracted cannot be definitely determined. Both the ultimate and penultimate rachises of the example given at fig. 1 show scattered punctations, but they are not observable on the specimen seen at fig. 2, where the rachises are not well preserved.

The structure and arrangement of the sporangia are beautifully seen on the specimen given at fig. 2, of which a portion is enlarged two times at fig. 2*a*.

The carbonaceous matter has almost entirely disappeared from the fossil except that preserved in the sporangia. Many of these have fallen off and are represented by an impression in the matrix as seen on fig. 2*a*. They are arranged without order and cover the whole surface of the pinnule, even obscuring the nervation. On the larger pinnules four sporangia are seen to occupy their whole width. In other cases the number is three. They are comparatively large, being about 0·75 mm. long and 0·50 mm. broad. Some are enlarged thirty-three times at figs. 3 and 4. Originally they have held an upright position on the limb of the pinnule, but as the result of pressure they now lie horizontally on its surface and impinge upon each other or even slightly overlap. Their oval form, with rounded base and pointed apex, is well seen in the figures given here. On many of the sporangia small fragments of mineral matter adhere to their outer surface, but others are practically free from it and show their cells distinctly, which appear to have been thick walled. These are fusiform and about three times longer than broad. The sporangia are exannulate.

Some of the sporangia were macerated and their spore-contents obtained. At fig. 5 the complete spore-contents of a sporangium are shown enlarged a hundred and five times. The spores are very numerous, circular, and smooth. Some spores enlarged two hundred and fifty times are given at fig. 6. These show their smooth surface and small triradiate ridge.

The whole characters of the genus are those of *Myriotheca* Zeiller. The sporangia are, however, twice the size of those of *Myriotheca Desaillyi* Zeiller,* but they are placed without order on the pinnule and cover its whole surface in a similar manner to those of the generic type. On *Myriotheca anglica* the pinnules have a pecopteroid appearance though they may be slightly contracted at their base, whereas in *Myriotheca Desaillyi* they are of a sphenopteroid type. This difference, however, does not militate against their being generically identical, for the form of the pinnule is of little value as an indication of the systematic position of the plant.

Though one cannot speak with any certainty as to the affinities of *Myriotheca anglica*, it is probably pteridospermous.

I am indebted to Mr W. Hemingway and the late G. H. Knott for my specimens of this species.

Distribution.—Only three examples of this rare species are known to me.

WESTPHALIAN SERIES.

North Derbyshire and Nottingham Coalfield.

Horizon: Black Shale Coal. *Locality:* Avenue No. 9 Colliery, Chesterfield (W. Hemingway and A. R. Horwood).

Yorkshire Coalfield.

Horizon: Black Bed or Better Bed Coal. *Locality:* Liversedge (G. H. Knott).

* *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, p. 186, pl. ix, figs. 19, 20, 1883; "Flore foss. bassin houil. de Valenciennes," p. 140, pl. xii, figs. 5, 5A, B.

Genus **Coseleya** Kidston.

1914. *Coseleya* Kidston, " Fossil Flora S. Staffordshire Coalfield," *Trans. Roy. Soc. Edin.*, vol. l, p. 97.

Description.—Sporangia pyriform, exannulate, sessile or with very short pedicel, attached spirally or in close verticils round the axis and forming dense masses, or placed on the rachis in two rows. Sporangia unassociated with sterile pinnules.

Remarks.—The general characters have been slightly enlarged in the above diagnosis to admit of species being included in the genus which have similarly formed sporangia but arranged on the rachis in two rows.

In the original description of the genus the sporangia were described as sessile, but the contracted base of the pyriform sporangia more or less assume the form of short pedicels (Pl. LXXVII, figs. 1*b*, 7, 8). In *Coseleya glomerata* they may be described as sessile, but the base in *Coseleya Barkeri* terminates in a slender pedicel-like stalk.

The sterile or foliar condition of the fructifications included in *Coseleya* is unknown.

The affinity of the genus is also uncertain, but probably it is pteridospermous.

Distribution.—The genus *Coseleya* has hitherto only been found in the Westphalian Series.

Coseleya glomerata Kidston.

Plate LXXVII, figs. 1, 1*a*, 1*b*, 2, 3, 4.

1914. *Coseleya glomerata* Kidston, " Fossil Flora of S. Staffordshire Coalfield," pt. iii, *Trans. Roy. Soc. Edin.*, vol. l, p. 97, pl. v, figs. 4, 4*a*, 5, 6 ; pl. x, fig. 4.

Description.—Rachis stout, slightly flexuous, with closely placed irregular, small, transverse bars. Pinnæ alternate, short, and entirely obscured by closely placed sporangia arranged spirally or in whorls. Sporangia pyriform, sessile, or shortly pedicellate and free. Apparently dehiscing by a longitudinal cleft on their ventral surface. Sterile condition of plant not known.

Remarks.—At fig. 1, Pl. LXXVII, the largest specimen of this fructification which has been discovered is shown natural size. The sporangia themselves have decayed and the groups have only left their impression in the matrix, accentuated by a brown stain. The same specimen is seen enlarged two times at fig. 1*a*. At the part marked *a* on this figure, one of the pinnæ has been broken over and shows the group of sporangia in section, where at one point the form of the sporangia can be clearly made out. Two of these are enlarged nine times at fig. 1*b*. They are pyriform and their contracted base acts as a short pedicel. A dark line is seen occasionally to run down the ventral face of the sporangia, and probably indicates the position of a longitudinal cleft by which dehiscence took place.

The stout main rachis of this specimen bears numerous little transverse bars. These were formerly supposed to mark the position of fallen scales, but there is now tolerably clear evidence to show that these little bars are due to a subepidermal structure and do not represent the scars of fallen scales as formerly believed.*

At figs 2 and 4 two other small specimens are shown enlarged two times. At *a* on fig. 2 the arrangement of the sporangia around the axis is well seen. It is difficult, however, to determine whether the sporangia are in whorls or spirally arranged on the rachis, but I rather think they are spirally placed. At the upper end of fig. 4 the form of the sporangia can be seen, but they occur in such dense masses that one sporangium generally tends to obscure the form of another, and the general appearance of these fertile pinnæ is as if the stem bore small bramble-like fruits, the "pips" being the impressions of the apices of the sporangia in the matrix. This is seen at fig. 3, which is enlarged two times.

Most probably in *Coseleya glomerata* we have the microsporangia of a pteridosperm. The transverse little bars of indurated tissue within the cortex, I think, point also to such an affinity.

All the specimens of *Coseleya glomerata* which I have seen were collected by Mr H. W. Hughes, F.G.S.

The generic name is derived from Coseley, near Dudley, where in the past so many fine specimens of fossil plants have been obtained.

Distribution.—Rare, and hitherto met with only at Coseley.

WESTPHALIAN SERIES.

South Staffordshire Coalfield.

Horizon: Ten-foot Ironstone Measures. *Locality;* Clayscroft openwork, Coseley, near Dudley.

Coseleya Barkeri Kidston n. sp.

Plate LXXVII, figs. 5, 5*a*, 6–9.

Description.—Rachis slender, longitudinally striated and apparently much divided. Sporangia attached to the rachis (alternate ?) by their slender pedicels in two opposite rows, 1·5 mm. long and about 0·60 mm. broad, free, pyriform, pointed at apex and contracted at base into a stalk-like pedicel. Surface cells of sporangium wall form oblique rows which give the surface an obliquely striated appearance. Sporangia unassociated with sterile pinnules.

Remarks.—The best specimen of this species which has come under my observation was collected by Mr W. R. Barker, Barnsley. It is seen natural size on Pl. LXXVII, fig. 5, and enlarged two times at fig. 5*a* where the general appearance of the plant can be better observed. The specimen, which is evidently only a fragment of a frond, is tripinnate, but probably the frond was further divided.

* See Huth, "Ueber die Epidermis von *Mariopteris muricata*," *Palæobotanische Zeitschrift*, Band i, No. 1, p. 7, pls. i, ii, 1912.

The ultimate pinnæ bearing the sporangia are placed close to each other, and through displacement they frequently overlap and form dense masses of sporangia as seen at the upper end of fig. 5*a*.

The rachises of different degrees are very slender and the sporangia are borne in two opposite rows. They seem to have been placed on the rachis alternately, but it is difficult to determine their exact relationship to each other. It is, however, best seen in fig. 7.

Many of the sporangia are very well preserved. When their form is completely shown they are pyriform and their upper end terminates in a small sharp point. This is clearly shown in fig. 8, which is enlarged twenty-five times. The same character is also observable on some of the sporangia seen at fig. 7. Very frequently, however, the extreme upper end of the sporangium seems to be pressed inwards and the true apex is hidden. The sporangia then appears to have an oval form similar to that given at fig. 9, which is also enlarged twenty-five times.

The sporangia vary in size, but this may be due to their different states of development. Some sporangia of varying size are seen in fig. 6, but the larger have a fairly constant length of about 1·5 mm. long with a breadth of about 0·60 mm. The contracted base gradually merges into a thin pedicel as seen at figs. 7, 8.

The surface cells of the sporangia are in many cases well seen. They are small, very narrow, and four or five times longer than broad. They run in oblique rows across the sporangia and cause the curious twisted and striated appearance which is seen in figs. 6 and 7, but especially in figs. 8, 9.

Coseleya Barkeri is easily distinguished from *Coseleya glomerata* by its pointed and distinctly pedicellate sporangia with obliquely striated walls and their position in two rows on the rachis.

My thanks for the specimen figured here are due to Mr W. R. Barker, after whom I have pleasure in naming the species.

Distribution.—Very rare, and only known to occur in the Westphalian Series.

WESTPHALIAN SERIES.

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley (W. R. Barker).

Cf. Coseleya sp.

Plate LXXVI, figs. 7, 7*a*.

Remarks.—At fig. 7, Pl. LXXVI, a small fructification is shown natural size, of which a part is enlarged eleven times at fig. 7*a*. The specimen shows a portion of a lateral and apparently dichotomous pinna which springs from the rachis seen at the base of the figure. On these small ultimate branchlets the sporangia are borne in little clusters. They are exannulate, oval, pointed at apex and rounded at base, and although they occur in groups, so far as can be observed they are free, but their exact relationship to each other is a little difficult to determine. They are of large size, being from 2 mm. to 2·5 mm. long and from 0·75 mm. to 1 mm. broad. The cells forming the walls of the sporangia are fusiform in shape, about four times longer than broad, and appear to have had thick walls.

Though the specimen is very small it is of interest as it shows a thick-walled type of exannulate sporangium, which, with slight modification in form and size, is characteristic of many Carboniferous fructifications, and which are most probably the microsporangia of pteridosperms.

The small specimen figured here is the only example of this fructification with which I have met.

CALCIFEROUS SANDSTONE SERIES.

CEMENTSTONE GROUP.

Horizon : Near base of group. *Locality :* Left bank of Crooked Stream, 50 yards below Newton Farm, Foulden, Berwickshire.

Genus **Ootheca** Nathorst.

1914 (22nd June). *Ootheca* Nathorst, " Foss. Flora d. Polarländer," Teil 1, Lief. 4, " Nachtrag z. Paläoz. Flora Spitzbergens," p. 19.

Description.—Sporangia oval, exannulate, free, placed singly, in pairs or in threes at the extremities of the ultimate divisions of the frond and unassociated with foliage pinnules.

Remarks.—As Nathorst found no satisfactory evidence to show that the sporangia, first described by him * as those of *Sphenopteris flexibilis* Heer, really belonged to that plant, he subsequently created for this fructification the genus *Ootheca.*

The genus *Ootheca* is closely related to the genus *Coseleya*, and differs from the latter only in the sporangia being borne at the ends of the branchlets, whereas in the former, they are attached distichously, or possibly spirally, to the rachis.

The fructifications placed in the genus *Ootheca* are probably the microsporangia of Pteridosperms.

Distribution.—The genus has hitherto been met with only in Lower Carboniferous rocks.

Ootheca globosa Kidston n. sp.

Plate LXXI, figs. 6, 6*a*.

Description.—Sporangia borne on the ultimate divisions of the frond, 2 mm. long, globose, slightly contracted at base into a short footstalk, exannulate, cells forming

* " Foss. Flora d. Polarländer," Teil 1, Lief. 1, p. 21, pl. iii, figs. 7, 8, 1894.

sporangium about twice as long as broad, with thick walls. Sporangia unassociated with foliage pinnules.

Remarks.—The specimen on which this species is founded is very small but the sporangia are well preserved. The fossil is seen natural size at fig. 6 and enlarged eleven times at fig. 6*a*. The sporangia are globose but contracted at base into a footstalk, and the cells of their walls seem to have been thick. This is shown on the enlarged figure.

Although the specimen is so small it exhibits an interesting type of sporangium. Though not very clearly shown, the apex of the branches seem to have dichotomized and at the end of each branchlet a single sporangium was borne. It is probable that *Ootheca globosa* shows the microsporangia of a pteridosperm.

Ootheca globosa is easily distinguished from *Ootheca Nordenskiōldii* Nathorst (the only other described member of the genus) by the globose form of its sporangia.

Distribution.—Only a single specimen of *Ootheca globosa* has been found at the undernoted locality.

CALCIFEROUS SANDSTONE SERIES.

CEMENTSTONE GROUP.

Horizon: Near base of the Group. *Locality:* Left bank of Crooked Stream, 50 yards below Newton Farm, Foulden, Berwickshire.

Genus **Radstockia** Kidston n.g.

1888. *Schizostachys* Kidston (*non* Grand' Eury), *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 351.
1891. *Schizostachys* Kidston (*non* Grand' Eury), *Trans. Geol. Soc. Glasgow*, vol. ix, p. 18.
1890. *Hymenotheca* Potonié (*pars*), "Ueber einige Carbonfarne," I, *Jahrb. k. preuss. geol. Landesanst. für 1889*, p. 21.
1899. *Acrocarpus* Potonié (*non* Schenk) (*pars*), "Lehrb. d. Pflanzenpal.," p. 104.

Description.—Fertile portion of frond lanceolate, bipinnate or tripinnate, rachis thick, straight, longitudinally striated. Ultimate pinnæ alternate, rachis stout, with fine longitudinal striations.

Sporangia on upper pinnæ single, sessile, or shortly pedicillate; on lower pinnæ most usually arranged alternately in pairs at the top of a short common pedicel, much more rarely united in groups of three or four large, attaining a length of 2·5 mm. to 6 mm., oval, straight, and have on upper surface a longitudinal furrow from the margins of which depart a series of close, delicate, transverse ridges.

Remarks.—The genus *Radstockia* is founded for the reception of the specimen originally described under the name of *Schizostachys sphenopteroides*,* and *Hymenotheca Beyschlagi* Potonié.†

The genus *Hymenotheca* is retained for the first species placed in it by Potonié,

* Kidston, *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 352, pl. xx, fig. 1, 1888.
† *Op. supra cit.*, p. 23, pl. iii.

the *Hymenotheca Dathei*,* which appears to differ essentially, so far as known, from the other plants he included in *Hymenotheca*. At a later date Potonié † merged his genus *Hymenotheca* in *Acrocarpus* Schenk,‡ but it is better to keep Carboniferous plants generically separate from those of Mesozoic rocks, especially as the structure and arrangement of the sporangia in Carboniferous species is still imperfectly known.

The essential character of the genus *Radstockia* is the terminal oval sporangia, whose surface shows a longitudinal furrow from which extend on both sides fine transverse bars that cover the whole surface of the structure, which here is believed to be a sporangium.

The transverse bars may represent a mechanical arrangement for opening the sporangium at maturity, though they may have served some other purpose.

The plants included in *Radstockia* have been referred to the Hymenophyllaceæ and Botryopterideæ. It seems more probable that the fertile organs they exhibit are large sporangia and not sori, but our knowledge of the nature of these "Sporangia" is so imperfect it is impossible to determine whether *Radstockia* should be placed with the Ferns or with the Pteridosperms.

Distribution.—The genus *Radstockia* is only known to occur in Upper Carboniferous rocks.

Radstockia sphenopteroides Kidston sp.

Plate LXXV, figs. 3, 3*a*.

1888. *Schizostachys sphenopteroides* Kidston, "Fossil Flora Somerset and Bristol Coalfield," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 352, pl. xx, figs. 1, 1*a*.

1891. *Hymenotheca sphenopteroides*, Potonié, "Ueber einige Carbonfarne," II, *Jahrb. k. preuss. geol. Landesanst. für 1890*, p. 13.

Description.—Frond (?) lanceolate, bipinnate, rachis stout, longitudinally striated. Pinnæ subopposite, linear lanceolate, close but not overlapping. Sporangia subopposite, close, and composed of two diverging sporangia on the lower pinnæ and a single sporangium on the upper ones. Sporangia oblong, with a middle furrow or line from both sides of which extend a series of transverse bars. Sterile condition of plant unknown.

Remarks.—The specimen is shown natural size on Pl. LXXV, fig. 3. No foliage pinnules occur in association with the sporangia, which form a row on each side of the rachis. On the lower pinnæ the diverging sporangia are in pairs, united at their base, and very shortly stalked or sessile. In only one case have three sporangia been observed to spring from a common point. These are seen at the base of the pinna third from the base of the specimen on the right side of the fossil.

The sporangia have a coriaceous appearance as if possessed of thick walls. The line on their face frequently appears as a slight furrow from which the transverse

* Potonié, *loc. cit.*, p. 21, pl. ii, figs. 1*a*, 1*b*, and 1*c*.

† "Lehrb. d. Pflanzenpal.," p. 104, 1899.

‡ "Die fossile Flora der Grenzschichten des Keupers und Lias Frankens," p. 134, 1867.

lines or small ridges run. Its appearance suggests the point at which dehiscence took place, but one cannot be certain of this or of the function performed by the transverse bars on the surface of the sporangia.

The affinities of *Radstockia sphenopteroides* are undetermined.

Distribution.—Very rare. The type specimen is the only one known to me.

RADSTOCKIAN SERIES.

RADSTOCK GROUP.

Horizon : ? *Locality :* Radstock, Somerset.

Genus **Hymenotheca** Potonié emend.

1890. *Hymenotheca* Potonié (*pars*), " Ueber einige Carbonfarne," *Jahrb. k. preuss. geol. Landesanstalt für 1889*, p. 21.

1899. *Acrocarpus* Potonié (? *non* Schenk) (*pars*), " Lehrbuch d. Pflanzenpal.," p. 104.

Description.—Frond tripinnate; rachis straight, winged; penultimate pinnæ lanceolate, alternate; rachis winged, straight or very slightly flexuous; ultimate pinnæ broadly lanceolate, alternate; rachis slightly flexuous, winged; pinnules alternate, close but generally free, of an oval contour, and divided into 2–4 broadly linear or elongated spreading segments, the fertile of which are obtuse and bear a more or less prominent elliptical or globular swelling at their apices, the nature of which is not understood. A single vein enters each segment of the pinnule.

Remarks.—The *Hymenotheca Dathei* Potonié is regarded as the type of this genus. It seems to differ from the other species included by Potonié in *Hymenotheca* in the structure of the organs placed at the apices of the fertile pinnule segments which do not undergo reduction. The terminal structure shows neither the longitudinal cleft nor the transverse bars extending from it which are distinctive of the sporangia of *Radstockia.* Nor does there seem to be any evidence by which it can be determined whether these elliptical or globular bodies are sporangia, or sori obscured by the presence of an indusium. The limb of the pinnules has been formed of very delicate tissue like that of the existing genus *Hymenophyllum*, but this of itself is quite insufficient to support the view that *Hymenotheca* has any affinity with the Hymenophyllaceæ. What the affinities of the genus are cannot be determined until the structure of the fertile organs is ascertained.

Hymenotheca acuta Kidston n. sp.

Plate LXXV, figs. 4, 4*a*, 5, 5*a–b*, 6.

Description.—Frond tripinnate. Secondary pinnæ; rachis straight with a central cord-like band passing up the middle, broadly winged, smooth. Sterile pinnules alternate, decurrent, oblique to rachis, attached by a broad base of rhomboidal contour and divided into three to five linear, sharp-pointed, sometimes slightly recurved, spreading segments, into each of which a vein enters; limb of pinnule formed of delicate tissue. Fertile pinnules alternate, with linear segments of almost equal width throughout, very obtuse, and bearing at their extremities a single circular or slightly oval structure which occupies the whole width of the segments but the function of which is unknown.

Remarks.—This species is only known from fragmentary, but in some cases very well preserved specimens. At fig. 4, Pl. LXXV, a small specimen is shown natural size, and is enlarged two times at fig. 4*a*. It shows the fragmentary remains of the upper portion of two secondary pinnæ which terminate in an acute point. The lower and middle pinnules are divided into three to four spreading and in some cases slightly recurved segments, which terminate in a sharp point. Another small fragment, of probably a secondary pinna, seen at fig. 6, shows the broadly winged rachis with the central cord-like band, which evidently represents the vascular strand.

A few fertile pinnules are given at fig. 5 natural size and enlarged two times at fig. 5*a*. The terminal structures are best seen on the fragment on the left side of the figure. The pinnule segments are very obtuse, of almost equal breadth, and terminate in a circular or oval body. These are well seen on the pinnule enlarged eleven times at fig. 5*b* and can only be described as circular or oval bodies. The single vein which enters the pinnule-segments ends at the base of these structures, but whether it extends beneath the terminal body or terminates against its lower margin cannot be determined. This enlarged figure also illustrates the surface appearance of the limb of the pinnule.

Hymenotheca acuta has considerable similarity to *Sphenopteris Sancti-Felicis* Stur sp.,* but the ultimate pinnæ are elongate-lanceolate while those of STUR's species are deltoid. The pinnules are also much more distant on our plant.

The form of the ultimate pinnæ and distant pinnules also distinguish our plant from *Hymenotheca Dathei* Potonié.†

Distribution.—*Hymenotheca acuta* has only been met with at one locality in the Westphalian Series.

WESTPHALIAN SERIES.

YORKSHIRE COALFIELD.

Horizon: Stanley Main Coal. *Locality:* Wakefield (W. HEMINGWAY).

* *Diplothmema Sancti-Felicis* Stur, "Carbon-Flora der Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 301, pl. xxix, fig. 1.

† *Jahrb. k. preuss. geol. Landesanstalt für 1889*, p. 21, pl. ii, fig. 1*a*–*c*, 1890.

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PLATE LXIX.

Fig. 1. *Hymenophyllites Bronni* Gutbier sp.
Fragment of a frond.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 2617.

Fig. 1*a*. *Hymenophyllites Bronni* Gutbier sp.
Portion of same specimen, enlarged two times to show form of pinnæ.

Fig. 1*b*. *Hymenophyllites Bronni* Gutbier sp.
Ultimate pinna, enlarged six and a half times to show form of the pinnule segmentation and the nervation.

Fig. 2. *Oligocarpia Brongniarti* Stur.
Fragment of a frond.
Locality.—Woolley Colliery, Darton, near Barnsley, Yorkshire.
Horizon.—Shale over Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1131.

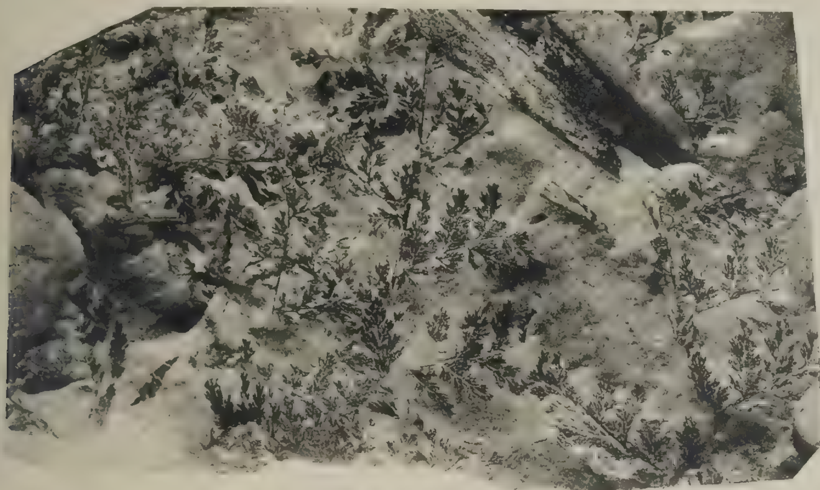
Fig. 2*a*. *Oligocarpia Brongniarti* Stur.
Pinnule from last specimen, enlarged six times to show form and nervation.

Fig. 3. *Oligocarpia Brongniarti* Stur.
Fragment of a frond.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 2909.

Fig. 3*a*. *Oligocarpia Brongniarti* Stur.
Pinnule from last specimen, enlarged six times to show form and nervation.

Fig. 4. *Corynepteris coralloides* Gutbier sp.
Portion of a frond.
Locality.—Glamorgan Colliery, Gilfach Goch, Glamorganshire.
Horizon.—No. 3 Rhondda Seam. Staffordian Series.
Natural size. Collected by Mr D. Davies, F.G.S. Kidston Collection, No. 5664.

Fig. 4*a*. *Corynepteris coralloides* Gutbier sp.
Ultimate pinnæ from last specimen, enlarged two times to show form of the pinnules.



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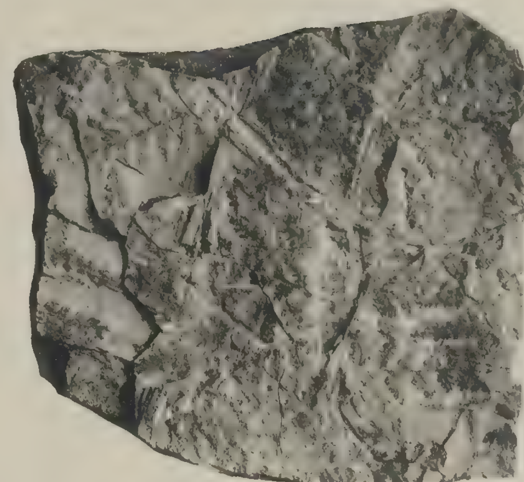

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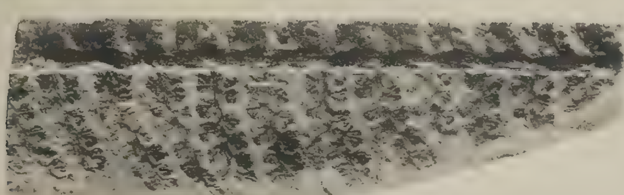

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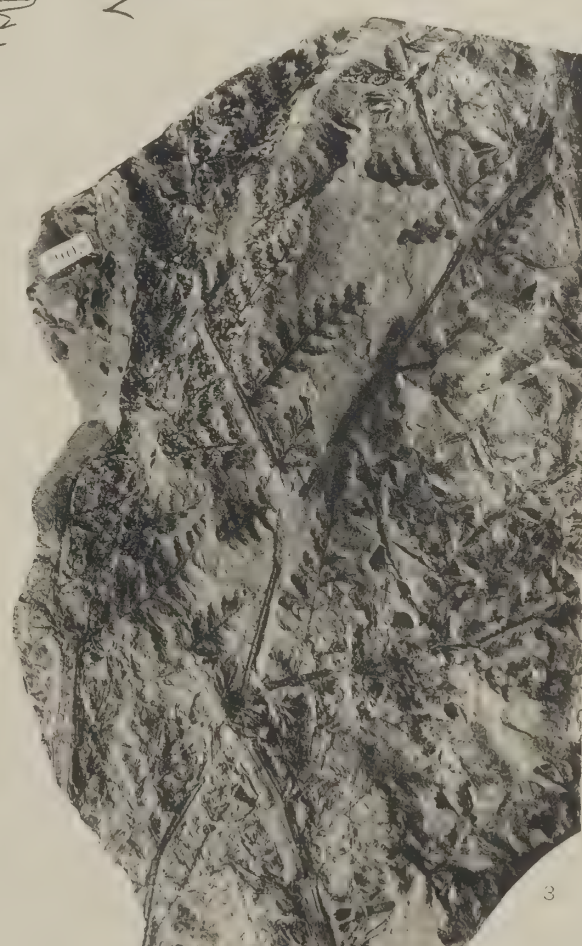
4



3

R Kidston

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PLATE LXX.

Fig. 1. *Oligocarpia Gutbieri* Göppert.

Fragments of fertile pinnæ.

Locality.—Bradford Colliery Sinking, Manchester.

Horizon.—Between 24 and 321 feet above Bradford Four-foot Coal. Staffordian Series, Blackband Group. Natural size. Kidston Collection, No. 3673.

Fig. 1*a*. *Oligocarpia Gutbieri* Göppert.

Fertile pinna enlarged two times to show distribution of the synangia.

From same specimen.

Fig. 1*b*. *Oligocarpia Gutbieri* Göppert.

Part of ultimate pinna, enlarged ten times to show synangia formed of three, four, and five sporangia. From same specimen.

Fig. 1*c*. *Oligocarpia Gutbieri* Göppert.

Synangia enlarged twenty-three times to show the component sporangia.

From same specimen.

Fig. 1*d*. *Oligocarpia Gutbieri* Göppert.

A synangium composed of five sporangia, enlarged fifty times, showing stomium on ventral surface. From same specimen.

Fig. 1*e*. *Oligocarpia Gutbieri* Göppert.

Spore contents of three sporangia of a synangium united to each other by the common walls of the spore cavities. Enlarged seventy-five times.

From macerated specimen.

Locality.—Sinking, New Gresford Colliery, 2 miles north of Wrexham, Denbighshire.

Horizon.—From between 116 yards and 192 yards from surface. Westphalian Series.

Fig. 1*f*. *Oligocarpia Gutbieri* Göppert.

Part of a synangium, showing the spore contents of two sporangia and the tissue forming the common connecting wall of the spore cavities. Enlarged two hundred and fifty times. From same specimen as last.

Fig. 1*g*. *Oligocarpia Gutbieri* Göppert.

Spores enlarged five hundred times, showing form and triradiate ridge. From macerated specimen. Same locality and horizon as last.

Fig. 2. *Oligocarpia Gutbieri* Göppert.

Penultimate pinna, apparently attached to rachis, showing the much-divided aphlebia.

Same locality and horizon as fig. 1.

Natural size. Kidston Collection, No. 3669.

Fig. 2*a*. *Oligocarpia Gutbieri* Göppert.

Same specimen as last, enlarged two times to show form of pinnules and segmentation of the aphlebia.

Fig. 2*b*. *Oligocarpia Gutbieri* Göppert.

Pinnule from same specimen, enlarged seven times to show form and nervation.

Fig. 2*c*. *Oligocarpia Gutbieri* Göppert.

Pinnules from same specimen, enlarged three and a half times.

Fig. 3. *Oligocarpia Gutbieri* Göppert.

Portion of fertile pinna attached to rachis, showing a very large aphlebia at the base of the figure.

Same locality and horizon as fig. 1. Natural size. Kidston Collection, No. 3671.

Fig. 3*a*. *Oligocarpia Gutbieri* Göppert.

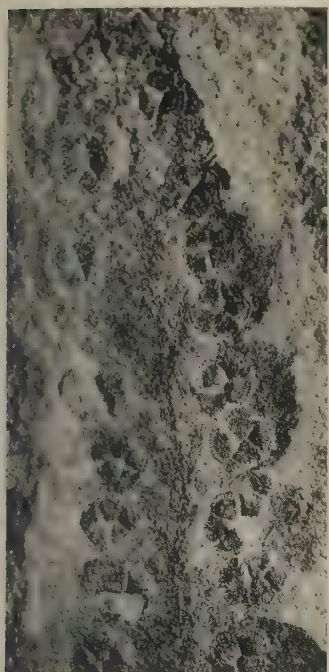
Aphlebia enlarged three and a half times to show segmentation from same specimen.

Figs. 1, 1*a–d*, 2, 2*a–c*, and 3, from specimens collected by Mr P. Whalley.

Figs. 1*e*, 1*f*, 1*g*, from specimen collected by Mr H. Hamshaw Thomas, M.A.

MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

Palaeontology Vol. II. 1923. Plate LXX.



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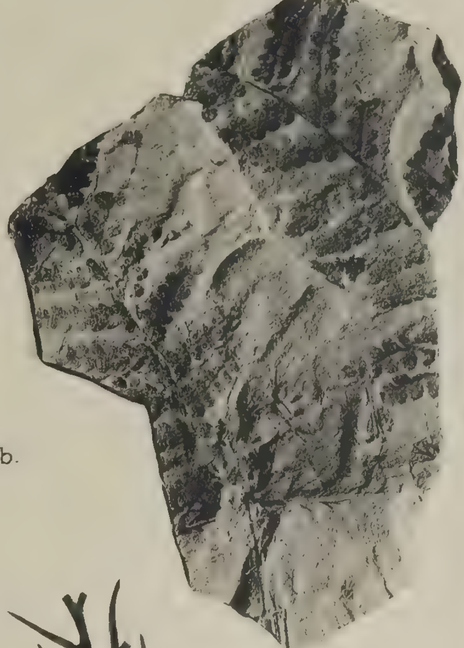

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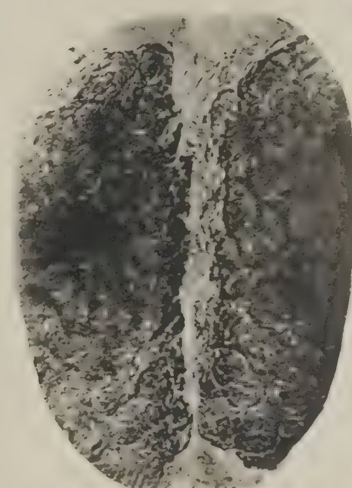

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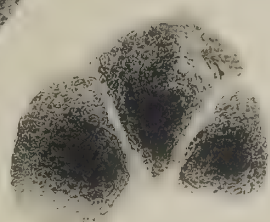

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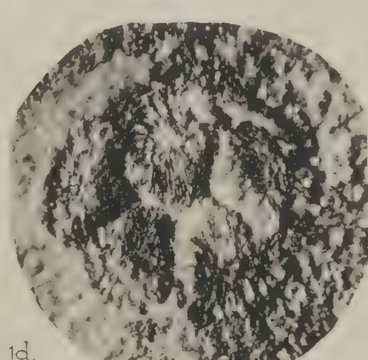

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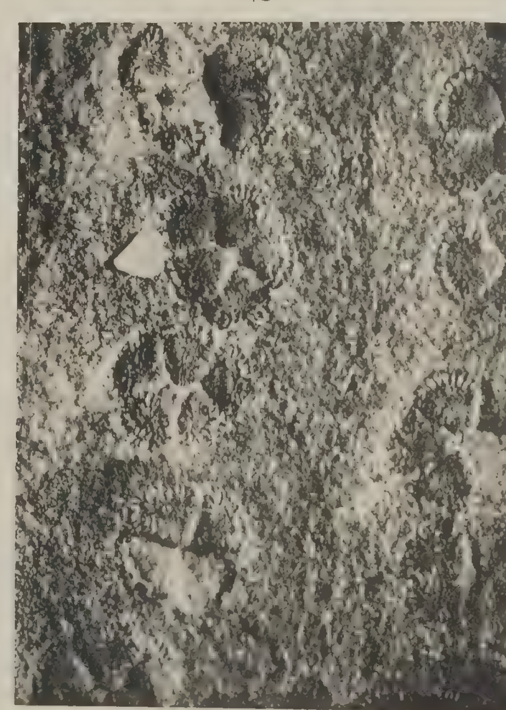

R Kidston. ZINCO COLLOTYPE CO. EDINBURGH

PLATE LXXI.

Fig. 1. *Boweria Schatzlarensis* Kidston.
Fragment of frond.
Locality.—Lane End, Fenton, Staffordshire.
Horizon.—Below Moss Coal. Westphalian Series.
Natural size. Collected by the late Dr W. Hind. Kidston Collection, No. 2013.

Fig. 1*a*. *Boweria Schatzlarensis* Kidston.
Portion of last specimen, enlarged two times to show segmentation of pinnules.

Fig. 1*b*. *Boweria Schatzlarensis* Kidston.
Two pinnules from same specimen, enlarged three and a half times.

Fig. 2. *Boweria Schatzlarensis* Kidston.
Fragment of frond.
Locality.—Woolley Colliery, Darton, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1521.

Fig. 2*a*. *Boweria Schatzlarensis* Kidston.
Pinnule from last specimen, enlarged six times to show form of segments and nervation.

Fig. 3. *Boweria Schatzlarensis* Kidston.
Portion of a fertile frond.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1245.

Fig. 3*a*. *Boweria Schatzlarensis* Kidston.
Fertile ultimate pinnæ, enlarged ten times to show segmentation of pinnules and position of the sporangia.
From the same specimen.

Fig. 3*b*. *Boweria Schatzlarensis* Kidston.
Fertile pinnule, enlarged twenty-five times to show the terminal position of sporangia on the lobes and the broad annulus.
From the specimen shown natural size at fig. 3.

Fig. 4. *Boweria Schatzlarensis* Kidston.
The two sporangia seen on fig. 3*b*, enlarged about sixty times.

Fig. 5. *Boweria Schatzlarensis* Kidston.
Spores enlarged five hundred times. The triradiate ridge is distinctly shown on the spore at the bottom of the figure.
From a sporangium taken from the counterpart of the specimen seen at fig. 3.

Fig. 6. *Ootheca globosa* Kidston.
Fragment of a rachis showing sporangia at apex.
Locality.—Left bank of Crooked Stream, 50 yards below Newton Farm, Foulden, Berwickshire.
Horizon.—Calciferous Sandstone Series. Cementstone Group.
Natural size. Kidston Collection, No. 4807.

Fig. 6*a*. *Ootheca globosa* Kidston.
The upper sporangial portion of the same specimen, enlarged eleven times to show the globular exannulate sporangia and the structure of their walls.

MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

Palaeontology Vol. II. 1923. Plate LXXI.


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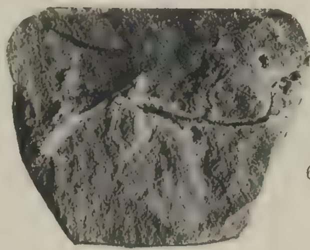
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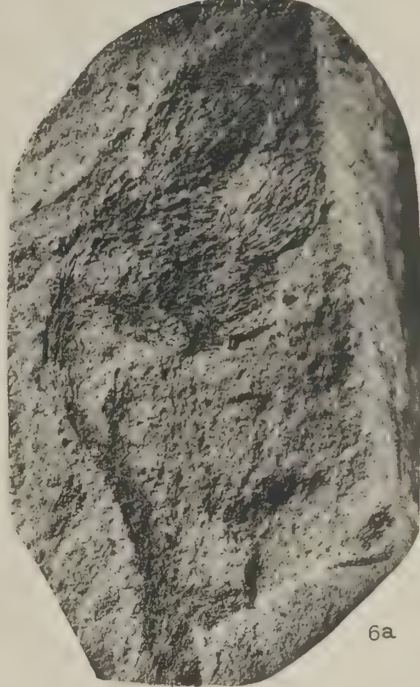
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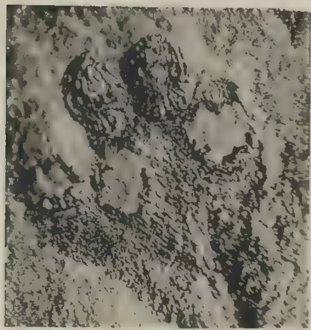
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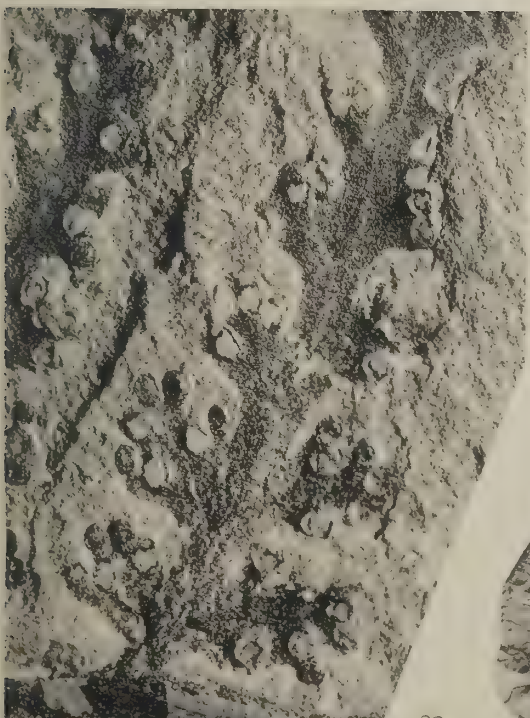
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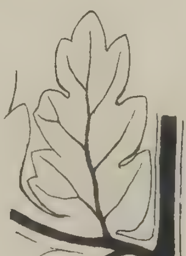
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PLATE LXXII.

Fig. 1. *Boweria minor* Kidston.
Fragment of frond.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 5030.

Fig. 1*a*. *Boweria minor* Kidston.
Portion of last specimen, enlarged two times to show form of pinnules.

Fig. 2. *Boweria minor* Kidston.
Fragment of a penultimate pinna.
Same locality and horizon.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 5038.

Fig. 2*a*. *Boweria minor* Kidston.
Same specimen, enlarged two times to show form of pinnules.

Fig. 2*b*. *Boweria minor* Kidston.
Two pinnules from specimen seen at fig. 2, enlarged seven and a half times to show their form and nervation.

Fig. 3. *Boweria minor*, Kidston.
Portion of primary punctate rachis, showing an aphlebia.
Same locality and horizon.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 5033.

Fig. 4. *Boweria minor* Kidston.
Portion of primary punctate rachis showing an aphlebia.
Same locality and horizon.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 5032.

Fig. 5. *Boweria minor* Kidston.
Fragments of pinnæ, one of which (*a*) is seen in circinate (*Spiropteris*) vernation.
Same locality and horizon.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 5037.

Fig. 6. *Boweria minor* Kidston.
Fertile pinnæ associated with fragments bearing sterile pinnules.
Same locality and horizon.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 5031.

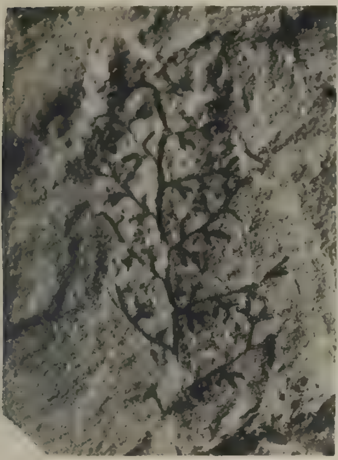
Fig. 7. *Boweria minor* Kidston.
Two sporangia, of which that at *a* overlies *b*, which only shows its annulus. Enlarged fifty times. From specimen seen at fig. 6.

Fig. 8. *Alloiopteris serrula* Lesquereux sp.
Fragment of an ultimate pinna.
Locality.—Glamorgan Colliery, Gilfach Goch, Glamorganshire.
Horizon.—No. 3 Rhondda Seam. Staffordian Series.
Natural size. Collected by Mr D. Davies. Kidston Collection, No. 5665.

Fig. 8*a*. *Alloiopteris serrula* Lesquereux sp.
Same specimen, enlarged two times to show form of pinnules.

Fig. 8*b*. *Alloiopteris serrula* Lesquereux sp.
Three pinnules, enlarged seven and a half times to show teeth and nervation of pinnules.
From the same specimen.

Plate LXXII.



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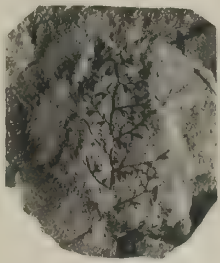

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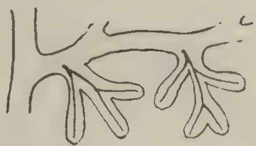

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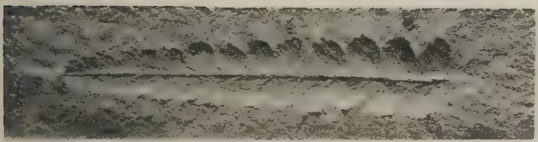

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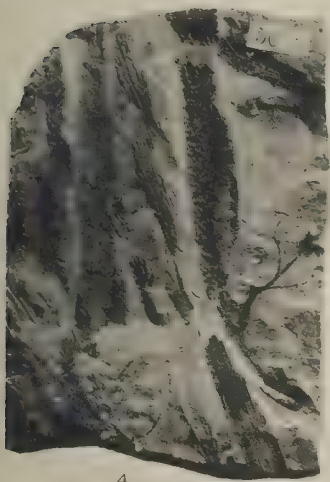

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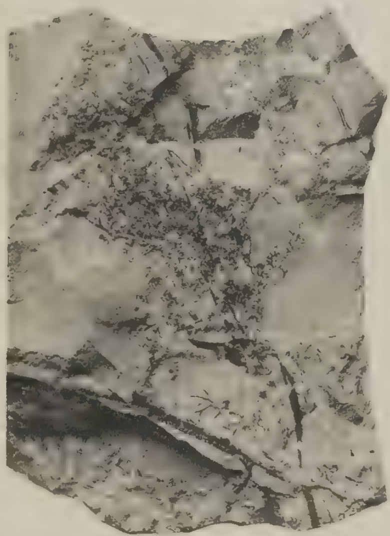

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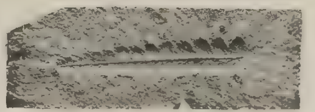

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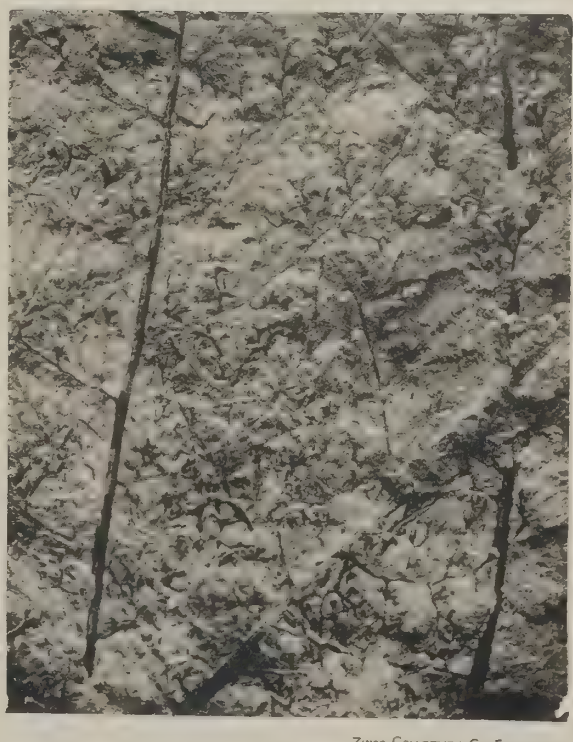

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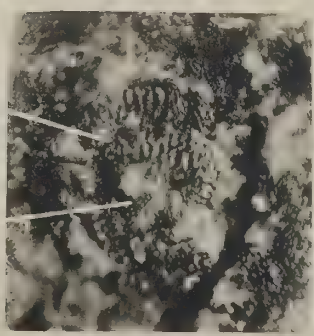

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PLATE LXXIII.

Fig. 1. *Alloiopteris Radstockensis* Kidston.
Portion of a frond.
Locality.—Braysdown Colliery, near Radstock, Somersetshire.
Horizon.—Radstockian Series. Radstock Group.
Natural size. Kidston Collection, No. 3826.

Figs. 1*a*–1*c*. *Alloiopteris Radstockensis* Kidston.
Portions of ultimate pinnæ, enlarged three and a half times to show form of pinnules.
From same specimen as last.

Fig. 2. *Corynepteris coralloides* Gutbier sp.
Fragment of a frond of a small form of the species.
Locality.—Newthorp Clay Pit (No. 1), Eastwood, Nottinghamshire.
Horizon.—Below Waterloo Coal. Westphalian Series.
Natural size. Collected by the late Dr L. Moysey, F.G.S.

Fig. 3. *Corynepteris coralloides* Gutbier sp.
Fragment of a penultimate pinna of a very small form of the species.
Same locality and horizon as last.
Collected by the late Dr L. Moysey, F.G.S.

Fig. 3*a*. *Corynepteris coralloides* Gutbier sp.
The specimen shown at fig. 3, enlarged two times.

Fig. 3*b*. *Corynepteris coralloides* Gutbier sp.
Ultimate pinna from same specimen, enlarged seven times to show form and segmentation of pinnules and their nervation.

Fig. 4. *Corynepteris coralloides* Gutbier sp.
Some pinnules of another specimen, enlarged ten times to show their form and nervation.
Same locality and horizon.

Fig. 5. *Corynepteris coralloides* Gutbier sp.
Fragment of a fertile specimen.
Same locality and horizon.
Natural size. Collected by the late Dr L. Moysey, F.G.S.

Fig. 5*a*. *Corynepteris coralloides* Gutbier sp.
The base of the figure shows the limit of a crushed group of sporangia, beyond which extends the apical portion of the limb of the pinnule to whose base the sporangia are attached.
From specimen seen at fig. 5. Enlarged ten times.

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PLATE LXXIV.

Fig. 1. *Corynepteris Sternbergi* Ettingshausen sp.
Fragment of a pinna.
Locality.—Brickwork, Hibson Road at Marsden Height, Nelson, Lancashire.
Horizon.—Outcrop of Arley Mine. Westphalian Series.
Natural size. Collected by Mr P. WHALLEY. Kidston Collection, No. 3405.

Fig. 2. *Corynepteris Sternbergi* Ettingshausen sp.
Fragments of pinnæ.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 1507.

Figs. 2*a* and 2*b*. *Corynepteris Sternbergi* Ettingshausen sp.
Pinnules from last specimen, enlarged six times to show their form and nervation.

Fig. 3. *Corynepteris Sternbergi* Ettingshausen sp.
A pinnule enlarged six times to show its form and nervation.
Same locality and horizon as fig. 1.
Collected by Mr P. WHALLEY. Kidston Collection, No. 3408.

Fig. 4. *Corynepteris coralloides* Gutbier sp.
Fragment of a frond of a very small form of the species.
Locality.—Newthorp Clay Pit (No. 1), Eastwood, Nottinghamshire.
Horizon.—Below Waterloo Coal. Westphalian Series.
Natural size. Collected by the late Dr L. MOYSEY.

Fig. 4*a*. *Corynepteris coralloides* Göppert sp.
Penultimate pinna of last specimen, enlarged two times to show the form of the pinnules.

Fig. 5. *Corynepteris Sternbergi* Ettingshausen sp.
Portion of a fertile pinna.
Locality.—Bondsmain Colliery, Temple Normanton, near Chesterfield, Derbyshire.
Horizon.—Between Deep Hard Coal and Silkstone Coal. Westphalian Series.
Natural size. Collection of Geological Survey, London, No. 32390.

Fig. 5*a*. *Corynepteris Sternbergi* Ettingshausen sp.
Entire spore contents of a sporangium, enlarged thirty-three times.
From specimen shown at fig. 5.

Fig. 5*b*. *Corynepteris Sternbergi* Ettingshausen sp.
Part of spore contents of a sporangium, enlarged one hundred and five times.
From same specimen.

Figs. 5*c*–5*d*. *Corynepteris Sternbergi* Ettingshausen sp.
Spores showing triradiate ridge, enlarged five hundred times.
From same specimen.

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Plate LXXIV.

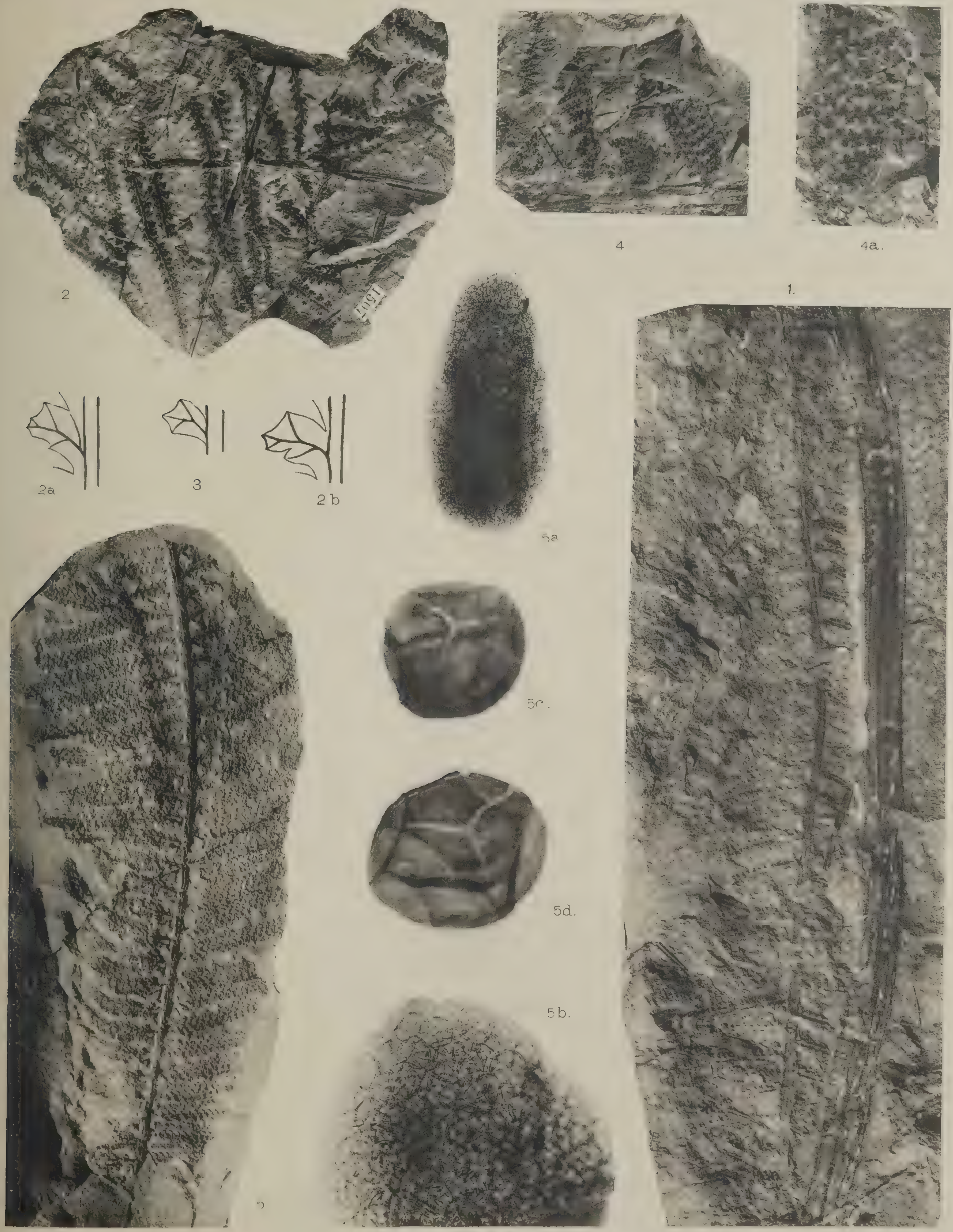

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PLATE LXXV.

Fig. 1. *Oligocarpia Gutbieri* Göppert.
Portion of a penultimate pinna.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 4226.

Fig. 2. *Oligocarpia Gutbieri* Göppert.
Portion of a penultimate pinna, enlarged two times to show the form of the pinnules.
Locality.—Bradford Colliery, Manchester.
Horizon.—Between 24–321 feet above Bradford Four-foot Coal. Staffordian Series. Blackband Group.
Collected by Mr P. WHALLEY. Kidston Collection, No. 4236.

Fig. 3. *Radstockia sphenopteroides* Kidston sp.
Portion of a fertile frond.
Locality.—Radstock, Somersetshire.
Horizon.—Radstockian Series. Radstock Group.
Natural size. Kidston Collection, No. 253.
Copy of figure by R. KIDSTON, "Fossil Flora of Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, pl. xx, fig. 1, 1888.

Fig. 3*a*. *Radstockia sphenopteroides* Kidston sp.
Sporangia enlarged three times to show the central furrow from which the small transverse bars on the surface of the sporangium extend.

Fig. 4. *Hymenotheca acuta* Kidston.
Portion of two sterile pinnæ.
Locality.—Wakefield, Yorkshire.
Horizon.—Stanley Main Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 1107.

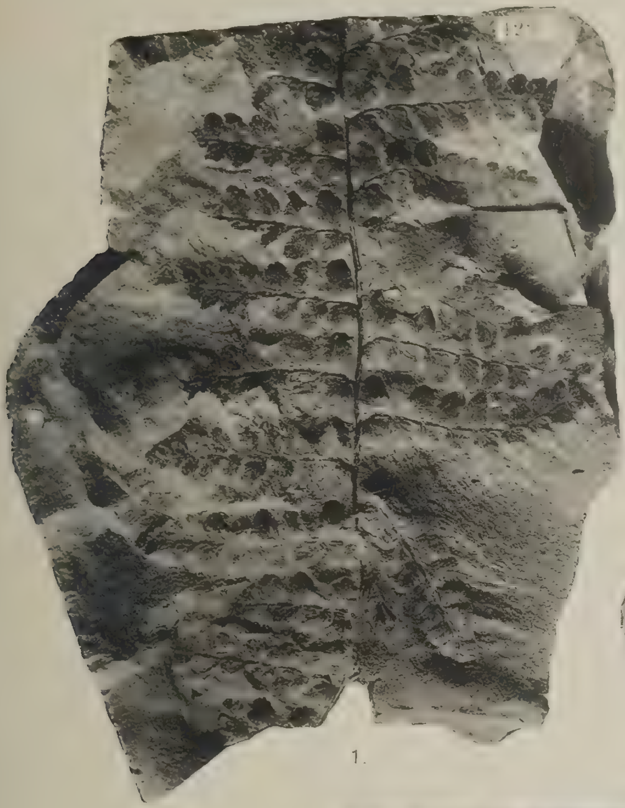
Fig. 4*a*. *Hymenotheca acuta* Kidston.
The same specimen enlarged two times to show the form of the pinnules.

Fig. 5. *Hymenotheca acuta* Kidston.
Two small fragments of fertile pinnæ.
Same locality and horizon.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 1108.

Fig. 5*a*. *Hymenotheca acuta* Kidston.
The last specimen enlarged two times to show the form of the pinnule segments and terminal fertile structure.

Fig. 5*b*. *Hymenotheca acuta* Kidston.
Fertile pinnule from specimen seen at fig. 5, enlarged eleven times to show the form of the terminal structure and the nervation.

Fig. 6. *Hymenotheca acuta* Kidston.
Fragment of a large pinna showing the winged rachis.
Same locality and horizon.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 1101.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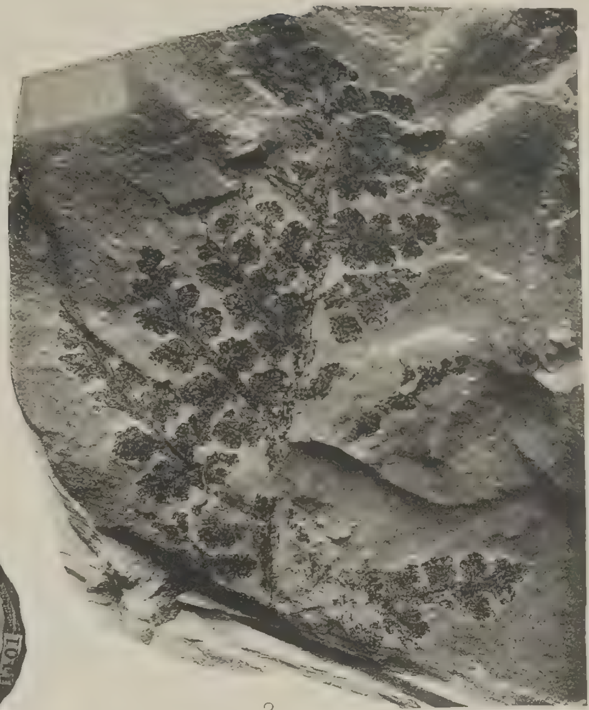
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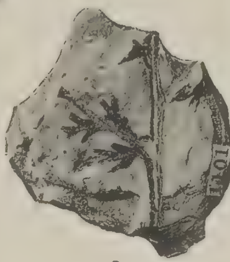
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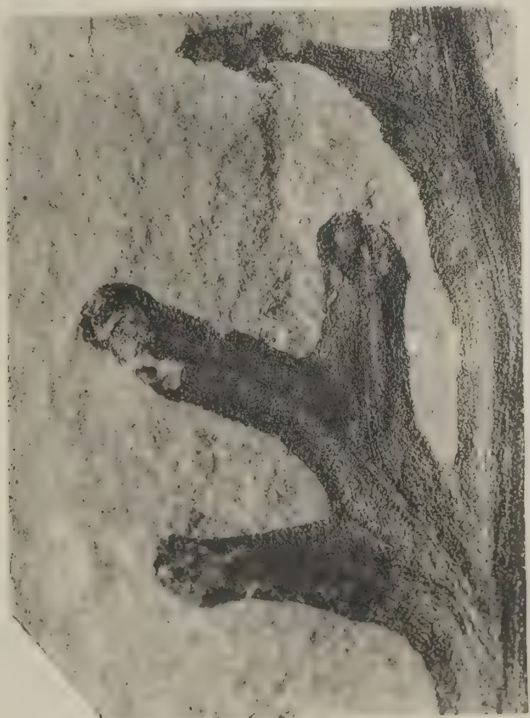
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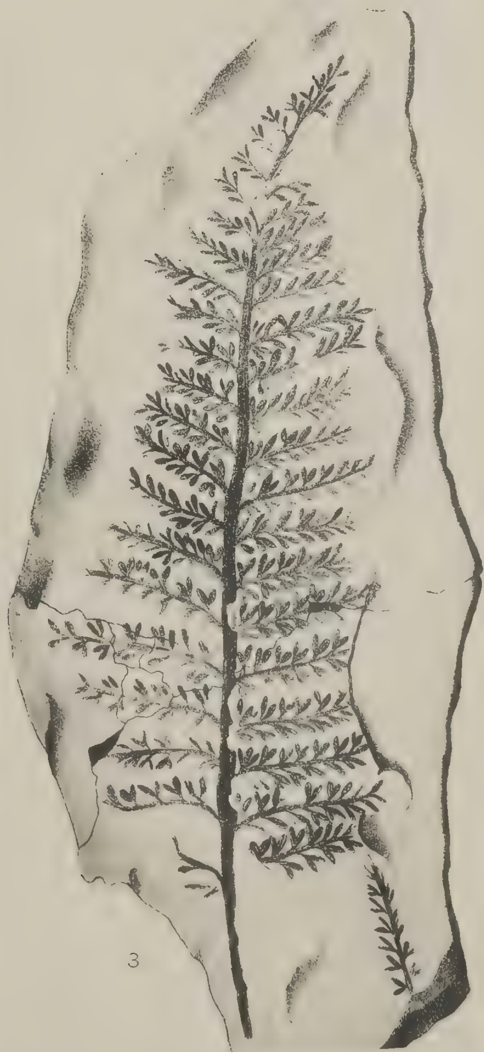
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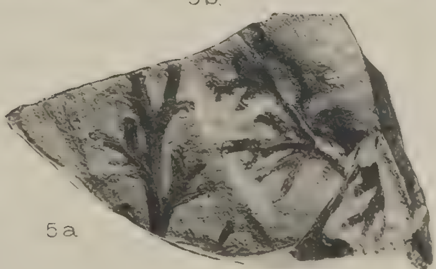
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PLATE LXXVI

Fig. 1. *Myriotheca anglica* Kidston.

Portion of a fertile frond.

Locality.—Avenue No. 9 Colliery, Chesterfield, Derbyshire.

Horizon.—Black Shale Coal. Westphalian Series.

Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 4146.

Fig. 2. *Myriotheca anglica* Kidston.

Portion of a fertile frond.

Locality.—Liversedge, Yorkshire.

Horizon.—Either from the Black Bed Coal or Better Bed Coal. Westphalian Series.

Natural size. Collected by Mr G. H. KNOTT. Kidston Collection, No. 3027.

Fig. 2*a*. *Myriotheca anglica* Kidston.

Portion of same specimen, enlarged two times to show arrangement of the exannulate sporangia on the pinnules.

Fig. 3. *Myriotheca anglica* Kidston.

An isolated exannulate sporangium showing its form and the structure of the sporangium wall. Enlarged thirty-three times.

From the same specimen.

Fig. 4. *Myriotheca anglica* Kidston.

Five exannulate sporangia. Those behind are partially obscured by mineral matter, those in front show well the cellular structure of the sporangium wall.

From the same specimen. Enlarged thirty-three times.

Fig. 5. *Myriotheca anglica* Kidston.

Complete spore contents of a sporangium. Enlarged one hundred and five times.

From the same specimen.

Fig. 6. *Myriotheca anglica* Kidston.

Spores, some of which exhibit a triradiate ridge. Enlarged two hundred and fifty times.

From the same specimen.

Fig. 7. Cf. *Coseleya* sp.

Small specimen showing exannulate sporangia unassociated with foliage pinnules.

Locality.—Left bank, Crooked Stream, about 50 yards below Newton Farm, Foulden, Berwickshire.

Horizon.—Calciferous Sandstone Series. Near base of Cementstone Group.

Natural size. Kidston Collection, No. 4804.

Fig. 7*a*. Cf. *Coseleya* sp.

A few exannulate sporangia of last specimen, enlarged eleven times to show their form and the structure of the sporangium wall.

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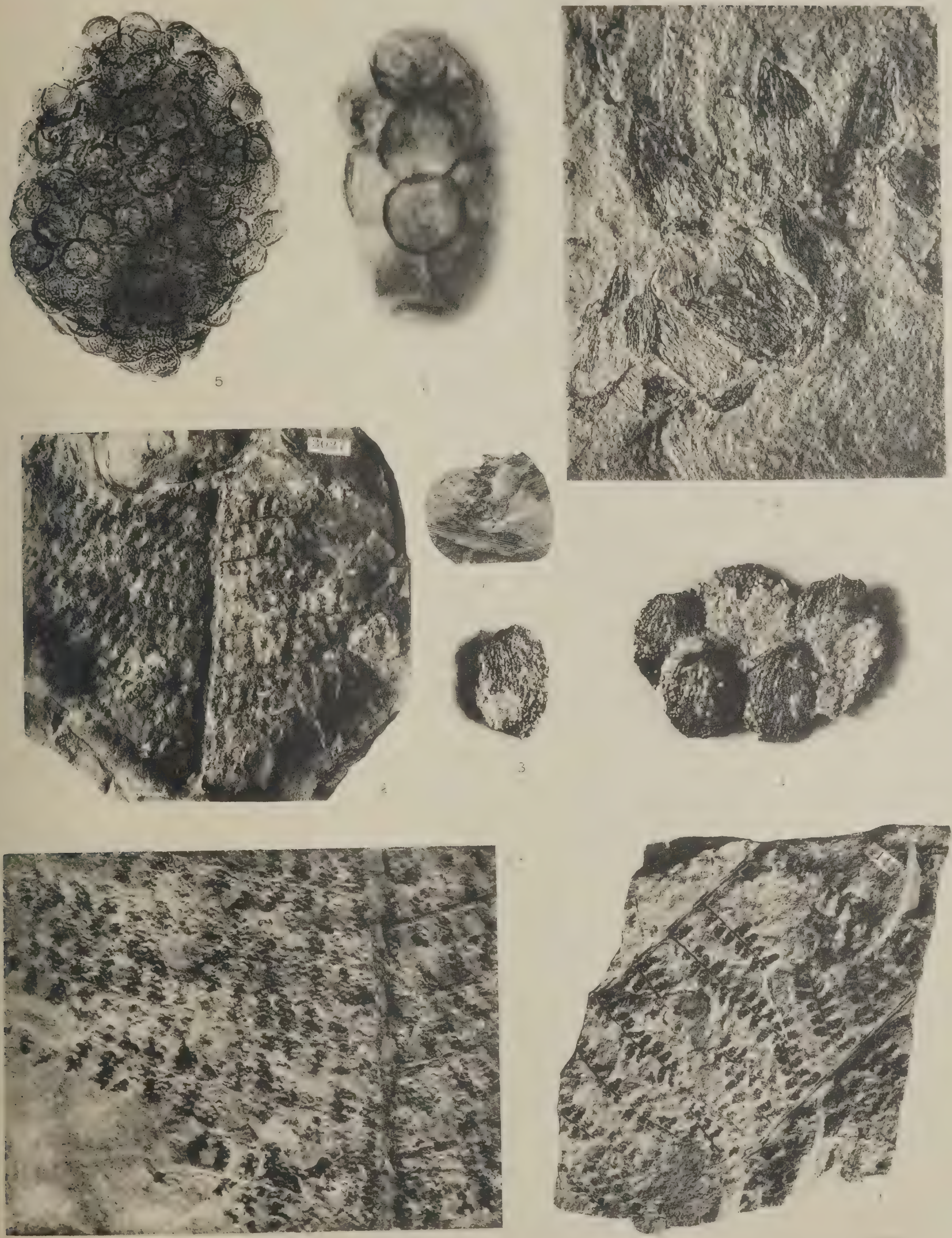

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PLATE LXXVII.

Fig. 1. *Coseleya glomerata* Kidston.
Fragment of fertile pinna showing sporangia clustered round the various axes.
Locality.—Clayscroft openwork, Coseley, near Dudley, South Staffordshire.
Horizon.—Ten-foot Ironstone Measures. Westphalian Series.
Natural size. Collection of Mr H. W. Hughes, F.G.S.

Fig. 1*a*. *Coseleya glomerata* Kidston.
Same specimen enlarged two times. At the broken pinna marked *a*, the sporangia are seen surrounding the rachis.

Fig. 1*b*. *Coseleya glomerata* Kidston.
Same sporangia from the part lettered *a* on fig. 1*a*, enlarged about nine times to show form of sporangia.

Fig. 2. *Coseleya glomerata* Kidston.
Fragment of a pinna, enlarged two times to show spiral or verticillate arrangement of sporangia at *a*.
Same locality and horizon as last.
Collection of Mr H. W. Hughes, F.G.S.

Fig. 3. *Coseleya glomerata* Kidston.
Small specimen, enlarged two times to show bramble-like appearance of masses of the sporangia.
Same locality and horizon.
Collection of Mr H. W. Hughes, F.G.S.

Fig. 4. *Coseleya glomerata* Kidston.
A small fragment enlarged two times to show form of sporangia.
Same locality and horizon.
Collection of Mr H. W. Hughes, F.G.S.

Fig. 5. *Coseleya Barkeri* Kidston.
Fragment of a fertile frond.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Kidston Collection, No. 5964.

Fig. 5*a*. *Coseleya Barkeri* Kidston.
Same specimen, enlarged two times to show form and arrangement of sporangia on the rachis.

Fig. 6. *Coseleya Barkeri* Kidston.
Sporangia from same specimen, enlarged eleven times to show their form and variation in size.

Fig. 7. *Coseleya Barkeri* Kidston.
Sporangia from same specimen, enlarged eleven times to show their contracted pedicel-like base and their mode of attachment to the rachis.

Fig. 8. *Coseleya Barkeri* Kidston.
Sporangia from same specimen, enlarged twenty-five times. All show the oblique arrangement of the rows of cells of the sporangial wall. The central specimen shows the apiculate apex of the pyriform sporangium.

Fig. 9. *Coseleya Barkeri* Kidston.
Sporangium enlarged twenty-five times to show the oblique arrangement of the cell rows of the sporangial wall. The upper end does not exhibit the true apex, which is bent underneath.
All enlargements from specimen shown natural size at fig. 5.

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Palaeontology. Vol. II. 1923. Plate LXXVII.

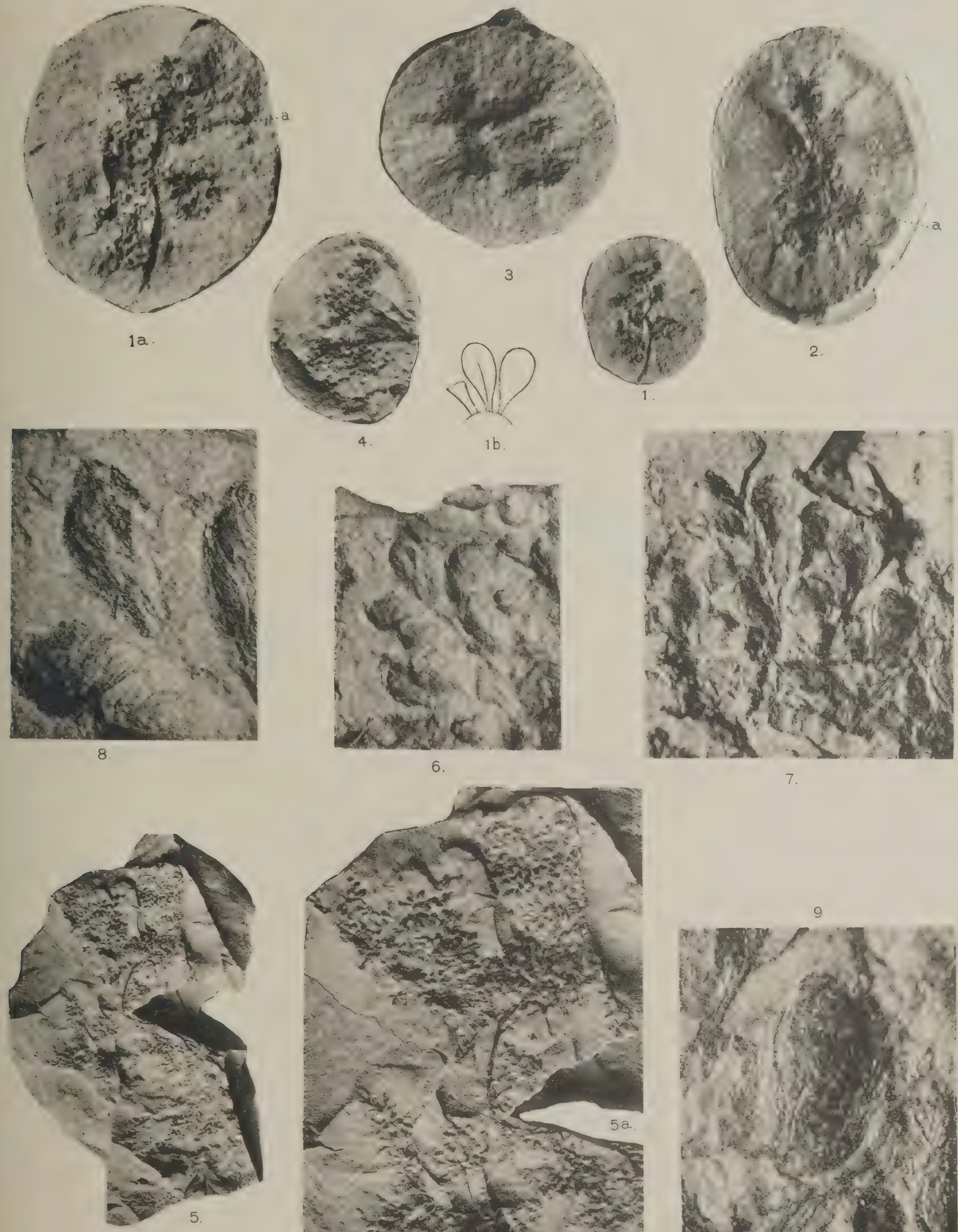

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PLATE LXXVIII.

Fig. 1. *Corynepteris Sternbergi* Ettingshausen sp.
Portion of a rachis giving off a primary pinna.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 1449.

Fig. 1*a*. *Corynepteris Sternbergi* Ettingshausen sp.
Same specimen enlarged two times to show apiculate rachis and an aphlebia in the lower angle of the pinna insertion, also the two thread-like vascular strands passing up the rachis.

Fig. 2. *Corynepteris Sternbergi* Ettingshausen sp.
Small specimen enlarged two times to show the flexuous vascular strand passing up the rachis, seen distinctly at *a*.
Locality.—Brickwork, Hibson Road at Marsden Height, Nelson, Lancashire.
Horizon.—Outcrop of Arley Mine. Westphalian Series.
Natural size. Collected by Mr P. WHALLEY. Kidston Collection, No. 3408.

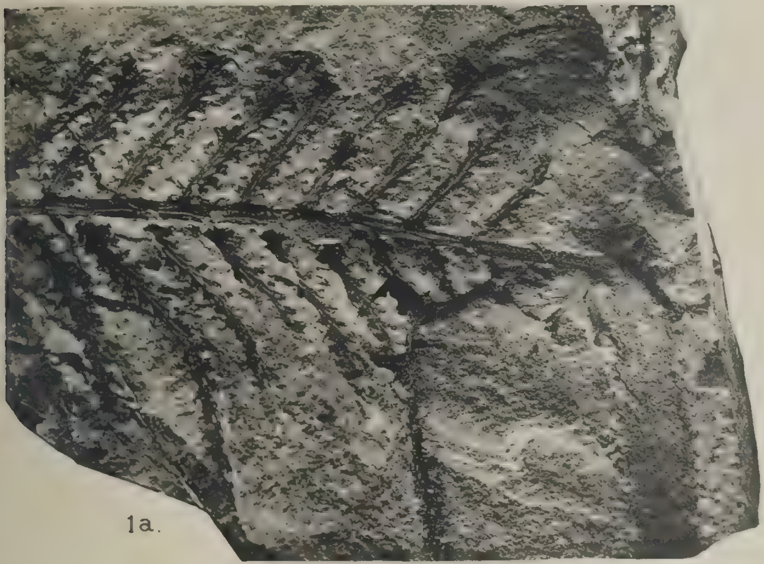
Fig. 3. *Renaultia chærophylloides* Brongniart sp.
Fragment of a penultimate pinna.
Locality.—Glamorgan Colliery, Gilfach Goch, Glamorganshire.
Horizon.—No. 3 Rhondda Seam. Staffordian Series.
Natural size. Collected by Mr D. DAVIES, F.G.S. Kidston Collection, No. 5658.

Fig. 3*a*. *Renaultia chærophylloides* Brongniart sp.
Part of last specimen, enlarged two times to show form of pinnules.

Fig. 3*b*. *Renaultia chærophylloides* Brongniart sp.
Pinnule from same specimen, enlarged seven times to show segmentation.

Fig. 4. *Renaultia chærophylloides* Brongniart sp.
Fragment of a frond.
Locality.—Hartley Bank Pit, Horbury, Yorkshire.
Horizon.—Roof of Old Hards Coal. Westphalian Series.
Natural size. Specimen in the Collection of the Sedgwick Museum, Cambridge, No. 887.

Fig. 4*a*. *Renaultia chærophylloides* Brongniart sp.
Portion of a penultimate pinna of last specimen, enlarged two times to show form of pinnules.



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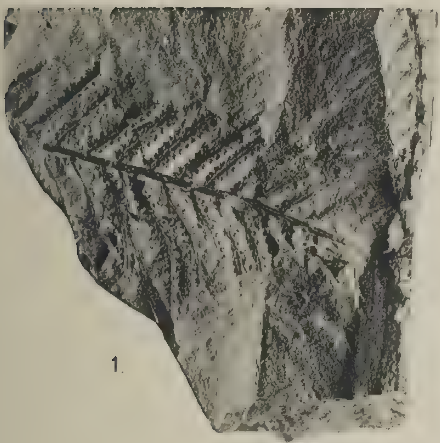

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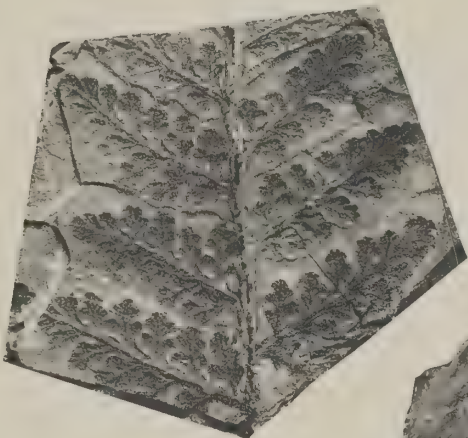

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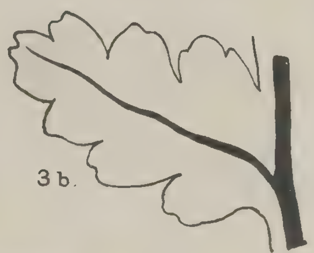

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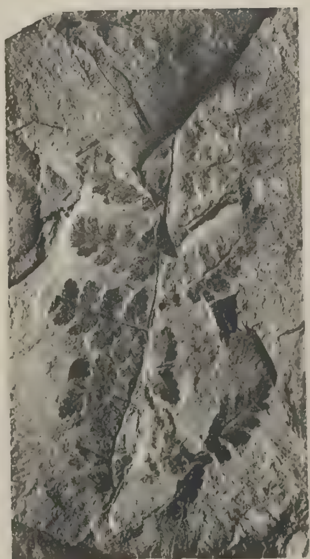

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PLATE LXXIX.

Fig. 1. *Renaultia gracilis* Brongniart sp.
Fragment of a penultimate pinna.
Locality.—Doulton's Clay Pit, Netherton, South Staffordshire.
Horizon.—Roof of Fireclay Clay. Westphalian Series.
Natural size. Collection of Mr H. W. Hughes, F.G.S.

Fig. 1*a*. *Renaultia gracilis* Brongniart sp.
Same specimen enlarged two times to show pinnule segmentation.

Fig. 2. *Renaultia gracilis* Brongniart sp.
Small fragment of a frond.
Locality.—Brickwork, Hibson Road at Marsden Height, Nelson, Lancashire.
Horizon.—Outcrop of Arley Mine. Collected by Mr P. Whalley.
Natural size. Kidston Collection, No. 3429.

Fig. 2*a*. *Renaultia gracilis* Brongniart sp.
Pinnules from same specimen, enlarged nine times to show form and nervation.

Fig. 3. *Renaultia gracilis* Brongniart sp.
Fragment of penultimate pinna.
Locality.—Shore, Blairpoint, Fife.
Horizon.—Near base of Coal-bearing Group. Lanarkian Series.
Natural size. Kidston Collection, No. 775.

Fig. 3*a*. *Renaultia gracilis* Brongniart sp.
Pinnules from last specimen, enlarged eight times to show segmentation and nervation.

Fig. 4. *Renaultia gracilis* Brongniart sp.
Fragment of a fertile specimen.
Locality and horizon same as last.
Natural size. Kidston Collection, No. 773.

Fig. 4*a*. *Renaultia gracilis* Brongniart sp.
Part of last specimen, enlarged two times to show form of pinnules.

Fig. 4*b*. *Renaultia gracilis* Brongniart sp.
Portion of same specimen, enlarged eleven times to show arrangement of sporangia.

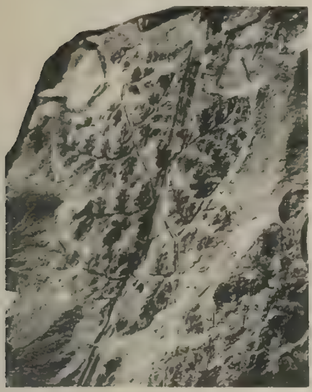
Figs. 4*c*–4*d*. *Renaultia gracilis* Brongniart sp.
Two pinnules from same specimen, enlarged to show the arrangement of the sporangia on the pinnules.

Fig. 4*e*. *Renaultia gracilis* Brongniart sp.
Sporangia from same specimen, enlarged twenty-five times to show varying form.

Fig. 4*f*. *Renaultia gracilis* Brongniart sp.
Two sporangia more highly magnified to show elongated form of cells of sporangium wall. From same specimen.

Fig. 4*g*. *Renaultia gracilis* Brongniart sp.
Spore contents of a sporangium enlarged one hundred and five times.
From counterpart of same specimen. Kidston Collection, No. 774.

Fig. 4*h*. *Renaultia gracilis* Brongniart sp.
A single spore enlarged five hundred times. From same specimen as last.



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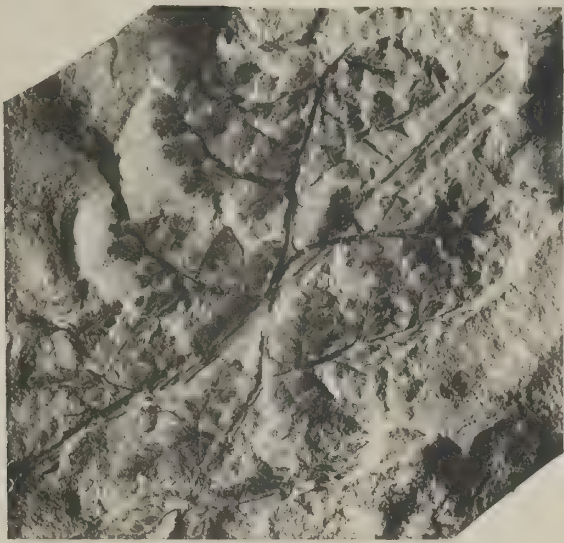

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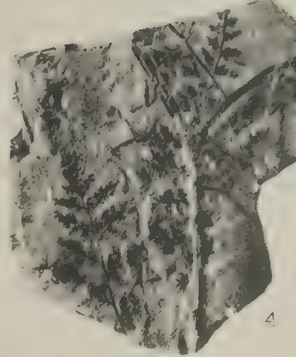

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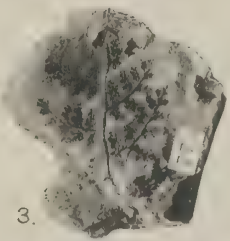

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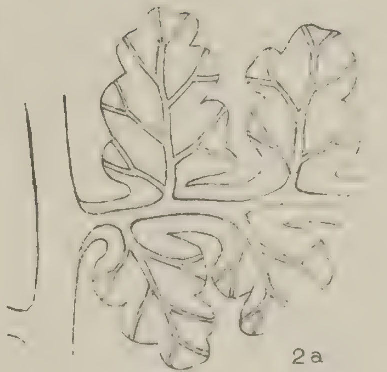

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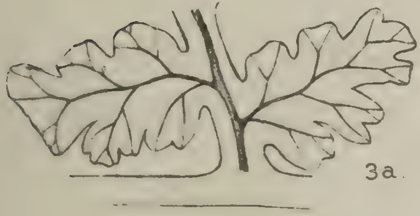

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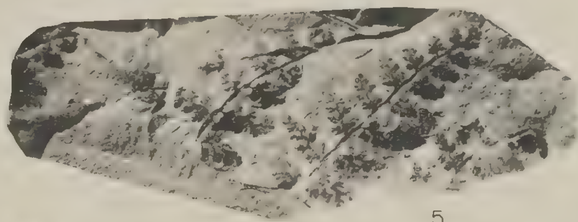

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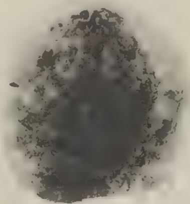

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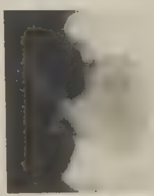

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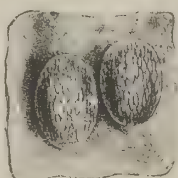

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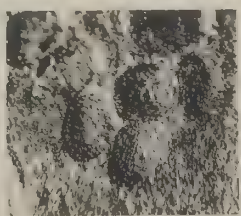

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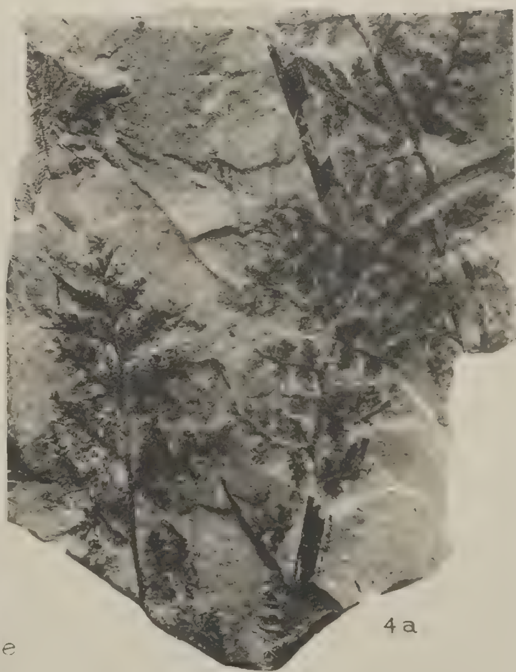

4a

PLATE LXXX.

Fig. 1. *Renaultia rotundifolia* Andrae sp.
Fragment of penultimate pinna.
Locality.—Granville Pit at Old Hill Station, South Staffordshire.
Horizon.—In upper 300 feet of Old Hill Marls. Staffordian Series. Etruria Marl Group.
Natural size. Collected by the Rev. H. Kay. Kidston Collection, No. 5957.

Fig. 1*a*. *Renaultia rotundifolia* Andrae sp.
Same specimen enlarged two times to show pinnule segmentation.

Fig. 2. *Renaultia rotundifolia* Andrae sp.
Fragment of penultimate pinna.
Same locality and horizon.
Natural size. Collected by the Rev. H. Kay. Kidston Collection, No. 5959.

Fig. 2*a*. *Renaultia rotundifolia* Andrae sp.
Same specimen enlarged two times to show pinnule segmentation.

Fig. 3. *Renaultia rotundifolia* Andrae sp.
Fragment of penultimate pinna.
Same locality and horizon.
Natural size. Collected by the Rev. H. Kay. Kidston Collection, No. 5960.

Fig. 4. *Renaultia rotundifolia* Andrae sp.
Fragment of penultimate pinna.
Locality.—Claycross, Derbyshire.
Horizon.—? Westphalian Series.
Natural size. Dr Pegler Collection. British Museum, No. V. 1855.

Figs. 4*a*–4*b*. *Renaultia rotundifolia* Andrae sp.
Pinnules from same specimen, enlarged three and a half times to show pinnule segmentation.

Fig. 5. *Renaultia rotundifolia* Andrae sp.
Fragment of frond enlarged two times to show geniculate rachis.
Locality and horizon same as fig. 1.
Collected by the Rev. H. Kay. Kidston Collection, No. 5958.

Figs. 6*a*–6*b*. *Renaultia rotundifolia* Andrae sp.
Two pinnules from specimen shown on Pl. XXX, fig. 1, enlarged to show form and nervation.
Locality.—West Thorley Colliery, Tow Law, County of Durham.
Horizon.—Five-quarter Seam. Westphalian Series.
In the Collection of Mr J. T. Stobbs, F.G.S.

Fig. 7. *Renaultia Crepini* Stur sp.
Fragment of frond.
Locality.—Dodworth near Barnsley.
Horizon.—Parkgate Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 3279.

Fig. 7*a*. *Renaultia Crepini* Stur sp.
Pinnule from same specimen, enlarged six times to show segmentation and nervation.

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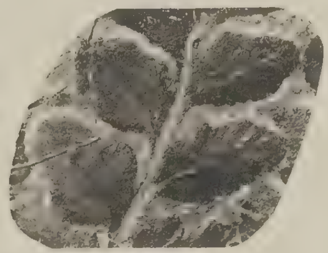

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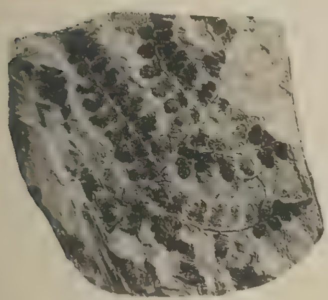

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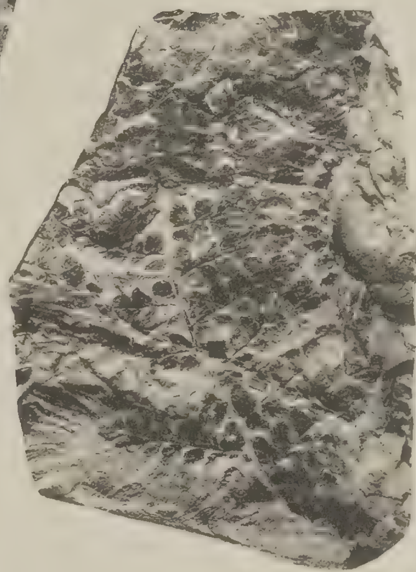

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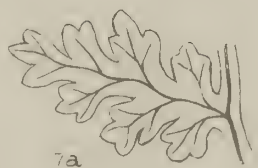

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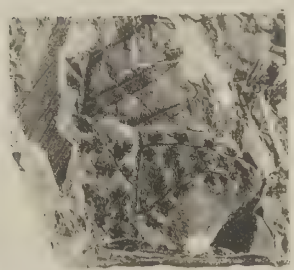

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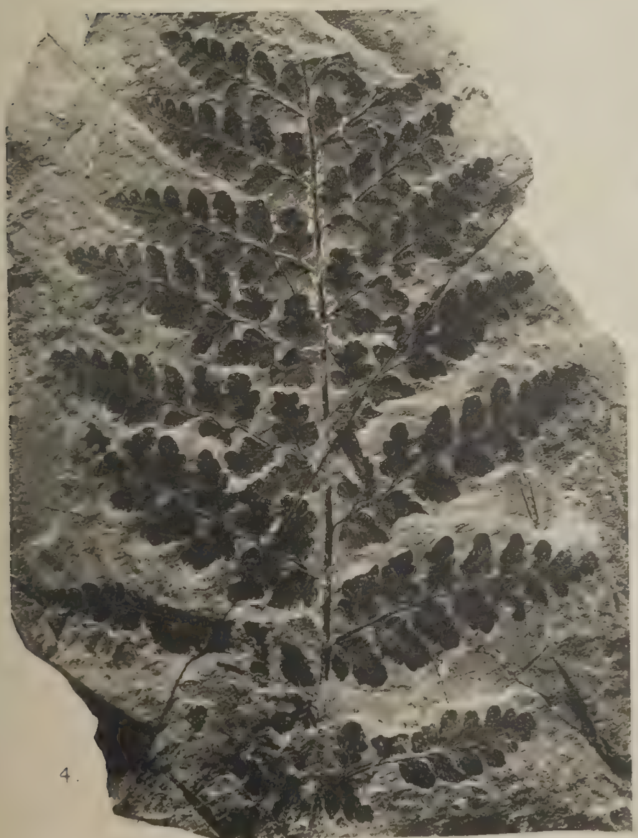

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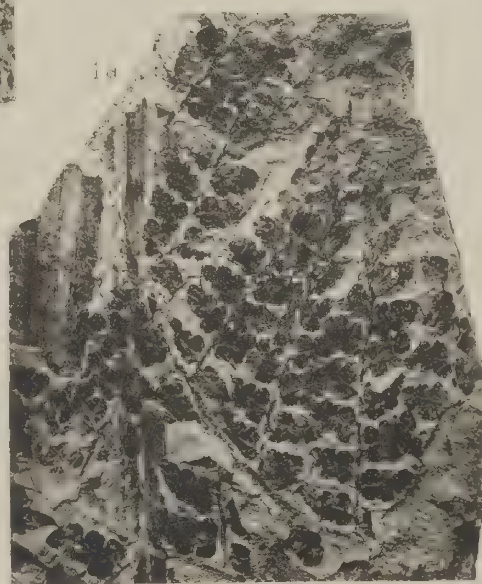

1a

6a

6b

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PLATE LXXXI.

Fig. 1. *Renaultia germanica* Potonié sp.

Fragment of a fertile frond.

Locality.—Ellismuir, Baillieston, Lanarkshire.

Horizon.—Kiltongue Coal. Lanarkian Series.

Natural size. Collected by Mr P. Jack. Now in the "Dunlop Collection," Pittencrieff Museum, Dunfermline.

Fig. 1*a*. *Renaultia germanica* Potonié sp.

Fertile pinnæ from last specimen, enlarged two times to show position of the numerous exannulate sporangia.

Fig. 2. ? *Renaultia* sp.

Fragment of a fertile penultimate pinna.

Locality.—Debris from Caledonian Railway bridge foundation, Calderbank, about 2 miles south of Airdrie, Lanarkshire.

Horizon.—Kiltongue Coal. Lanarkian Series.

Natural size. Collected by Mr R. Dunlop. Kidston Collection, No. 172.

Fig. 2*a*. ? *Renaultia* sp.

Same specimen, enlarged two times to show position of sporangia on pinnules.

Fig. 3. ? *Renaultia* sp.

Small fragments of fertile pinnæ.

Same locality and horizon.

Natural size. Collected by Mr R. Dunlop. Kidston Collection, No. 175.

Fig. 3*a*. ? *Renaultia* sp.

Last specimen enlarged two times to show position of sporangia on pinnules.

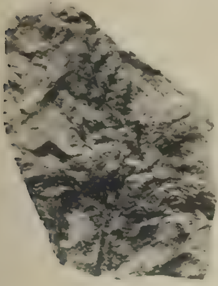
Fig. 4. ? *Renaultia* sp.

Small fragment of a sterile pinna, enlarged two times to show form and segmentation of pinnules.

Same locality and horizon.

Collected by Mr R. Dunlop. Kidston Collection, No. 171.

Plate LXXXI.



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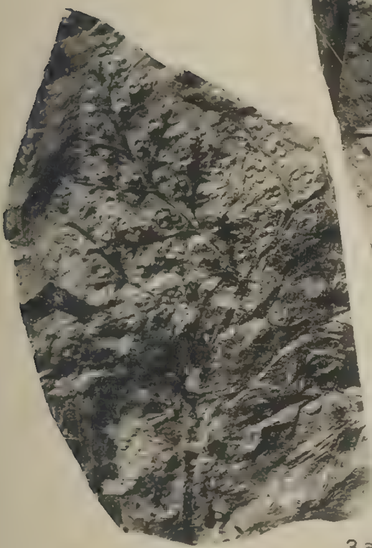

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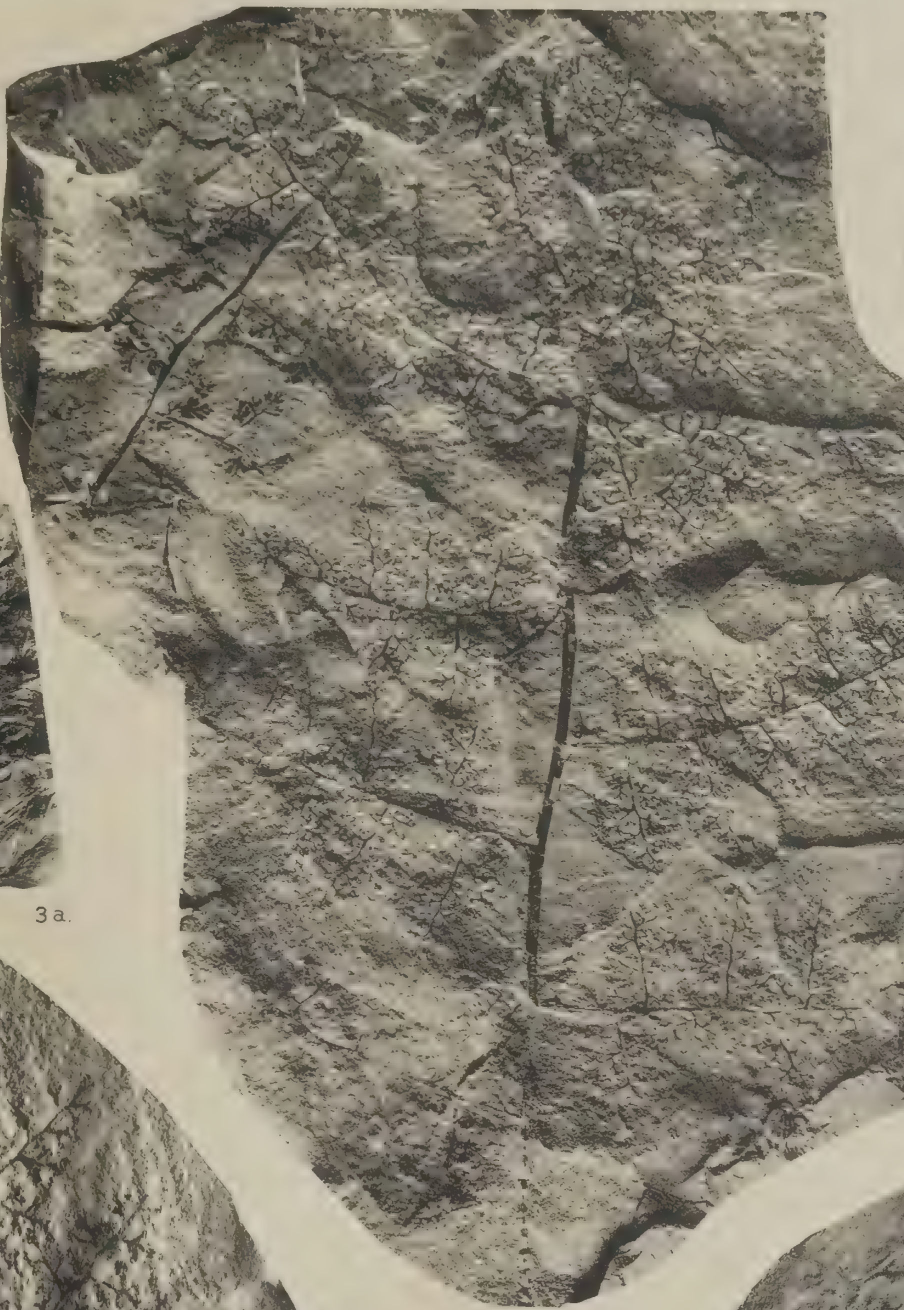

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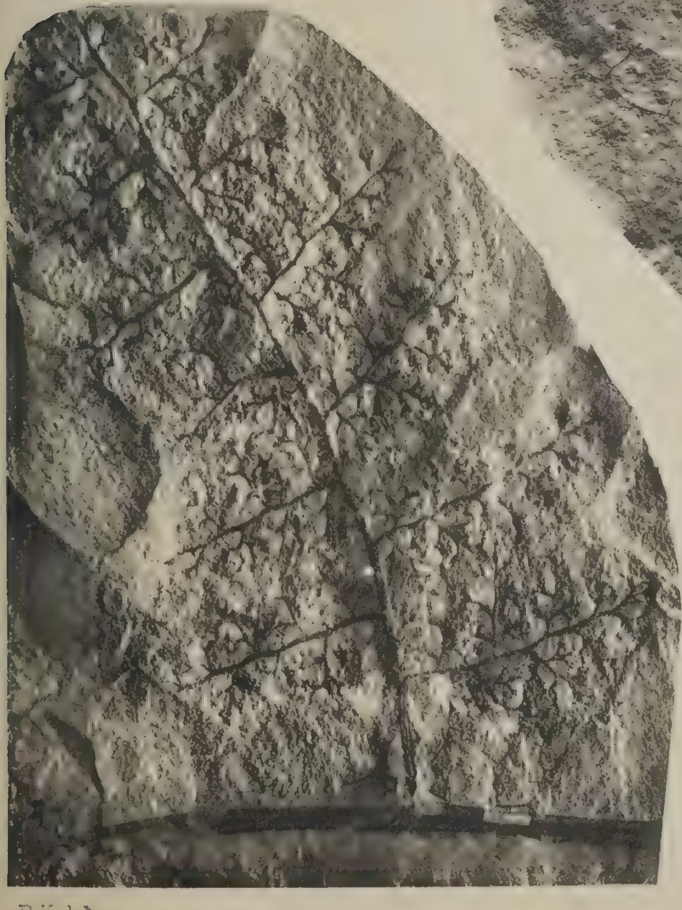

1 a

2.

2 a

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PLATE LXXXII.

Fig. 1. *Renaultia Hemingwayi* Kidston.

Fragment of a frond. The arrow at the base indicates the position of the aphlebia shown at fig. 1*c*. Small fragments of fertile pinnæ are seen at the upper right-hand corner.

Locality.—Bradford Colliery, Manchester.

Horizon.—From between 24 feet to 321 feet above Bradford Four-foot Coal. Blackband Group. Staffordian Series.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 3599.

Figs. 1*a*–1*b*. *Renaultia Hemingwayi* Kidston.

Ultimate pinnæ, enlarged three and a half times to show form of pinnules and their segmentation.

From the same specimen.

Fig. 1*c*. *Renaultia Hemingwayi* Kidston.

The imperfect aphlebia, whose position is indicated by the arrow on fig. 1, enlarged three times.

Fig. 2. *Renaultia Hemingwayi* Kidston.

Portion of a frond showing both sterile and fertile pinnæ.

Locality and horizon unknown, but most probably from the Lancashire Coalfield.

Natural size. Specimen in the "Dawes Collection," Museum, University, Manchester.

Fig. 2*a*. *Renaultia Hemingwayi* Kidston.

Portion of a fertile pinna, enlarged two times to show the great number of sporangia borne on the pinnæ.

From same specimen.

Fig. 2*b*. *Renaultia Hemingwayi* Kidston.

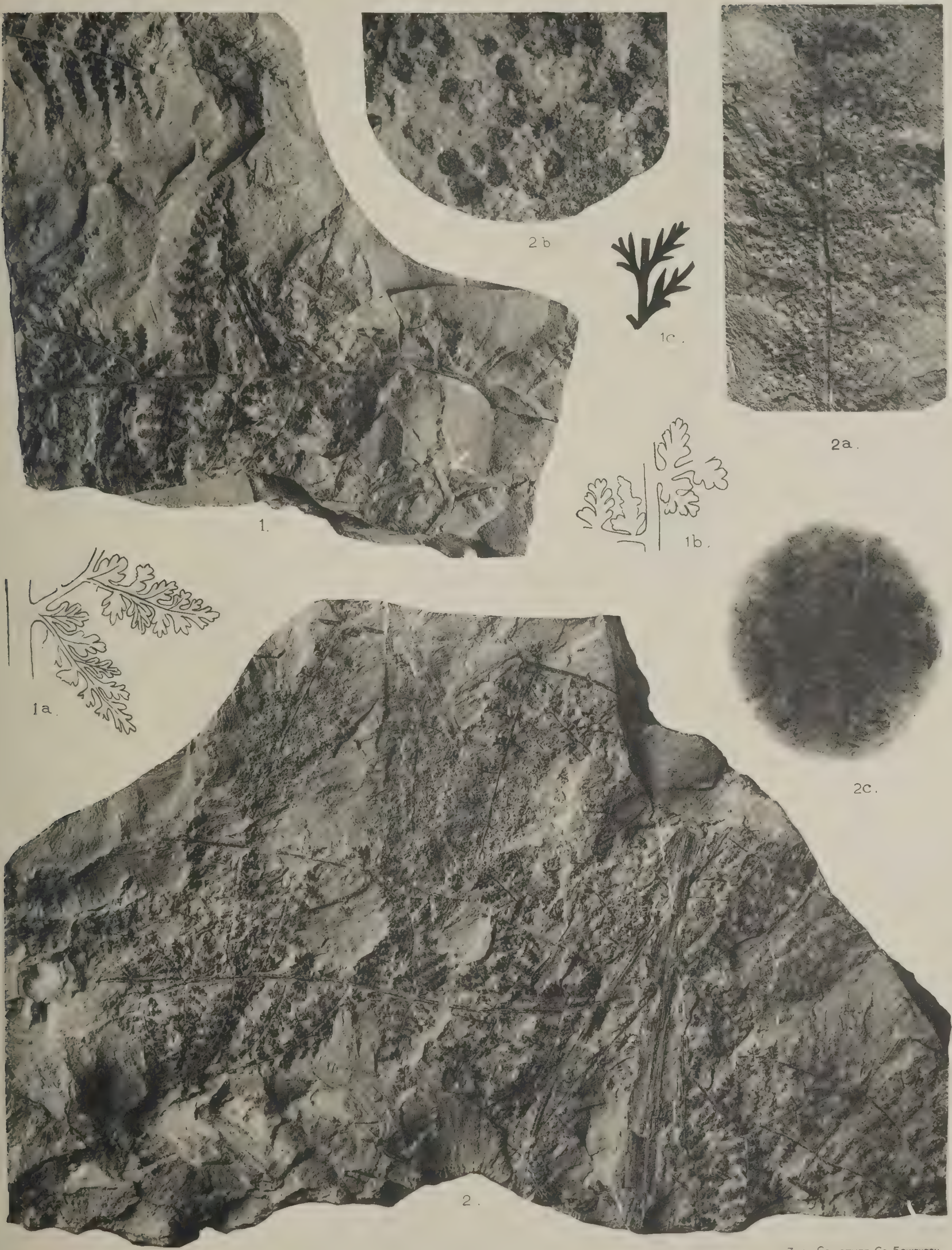
A few of the small exannulate sporangia, enlarged twenty-seven times.

From the same specimen.

Fig. 2*c*. *Renaultia Hemingwayi* Kidston.

Immature spore contents of a sporangium, enlarged two hundred and fifty times.

From same specimen.



1. 2 b 1c. 2a. 1b. 2c. 1a. 2.

R Kidston.

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PLATE LXXXIII.

Fig. 1. *Urnatopteris tenella* Brongniart sp.

Fragments of pinnæ.

Locality.—Devon Pit at Old Devon Ironworks, 1 mile south-west of Tillicoultry, Clackmannanshire.

Horizon.—Bed of blaes lying between Five-foot Coal and the Three-foot Splint Coal. Lanarkian Series.

Natural size. Kidston Collection, No. 2403.

Fig. 1*a*. *Urnatopteris tenella* Brongniart sp.

Portion of last specimen enlarged two times to show the form and arrangement of the pinnules.

Fig. 2. *Urnatopteris tenella* Brongniart sp.

Fragments of pinnæ.

Same locality and horizon as last specimen.

Natural size. Kidston Collection, No. 1983.

Fig. 2*a*. *Urnatopteris tenella* Brongniart sp.

Last specimen enlarged two times to show the arrangement of the pinnules and their segmentation on the more dense form of the plant with smaller pinnules.

Fig. 3. *Urnatopteris tenella* Brongniart sp.

Upper portion of a fertile frond.

Same locality and horizon.

Natural size. Kidston Collection, No. 1988.

Fig. 4. *Urnatopteris tenella* Brongniart sp.

Portion of a fertile frond, enlarged about two times to show the sporangia arranged on two rows on the rachis.

Locality.—Ellismuir, Baillieston, Lanarkshire.

Horizon.—Kiltongue Coal. Lanarkian Series.

Collected by Mr P. Jack. Kidston Collection, No. 2450.

Fig. 5. *Urnatopteris tenella* Brongniart sp.

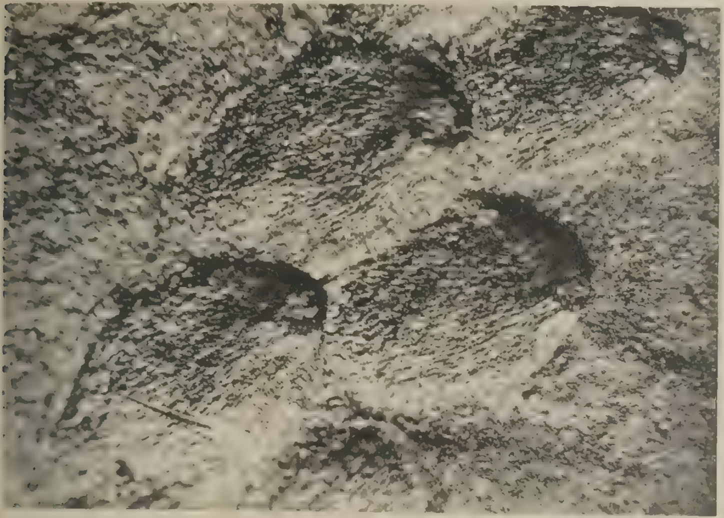
A few sporangia showing their arrangement on the rachis in two rows, their oval form and terminal pore.

Same locality and horizon as fig. 1.

Enlarged eleven times. Kidston Collection, No. 1970.

Fig. 5*a*. *Urnatopteris tenella* Brongniart sp.

Four sporangia from the same specimen as last, enlarged thirty-three times to show the form of the cells forming the sporangial wall and the terminal pore.



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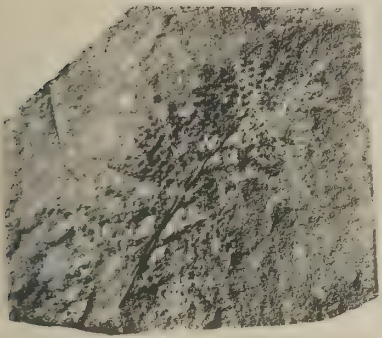

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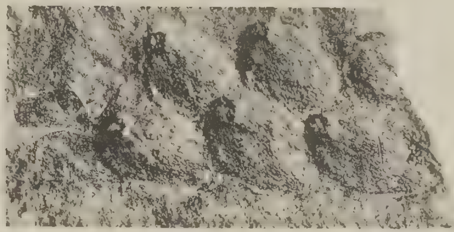

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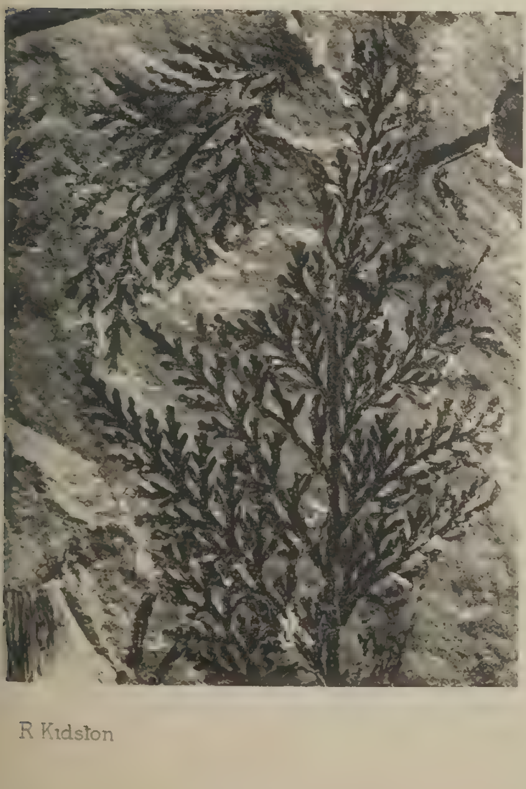

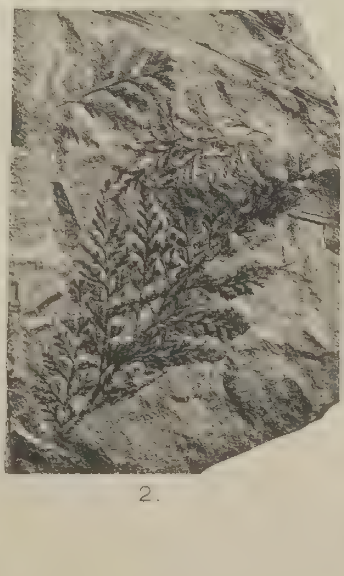

2.

1a.

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PLATE LXXXIV.

Fig. 1. *Urnatopteris tenella* Brongniart sp.

Portion of a fertile frond.

Locality.—Devon Pit at Old Devon Ironworks, 1 mile south-west of Tillicoultry, Clackmannanshire.

Horizon.—Bed of blaes lying between the Five-foot Coal and the Three-foot Splint Coal. Lanarkian Series. Natural size. Kidston Collection, No. 888.

Fig. 2. *Urnatopteris tenella* Brongniart sp.

Complete spore contents of a sporangium from the specimen shown on Pl. LXXXIII, fig. 4. Enlarged fifty times.

Fig. 3. *Urnatopteris tenella* Brongniart sp.

Spores from the same specimen, enlarged about two hundred and seventy-five times.

Fig. 4. *Urnatopteris herbacea* Boulay sp. Fragment of a pinna.

Locality.—Boring at Tower Brickworks, Folkestone, Kent.

Horizon.—At depth of 1768 feet. Staffordian Series.

Natural size. Collection of Geological Survey, London, No. 32389.

Fig. 5. *Urnatopteris herbacea* Boulay sp.

Part of same specimen, enlarged two times.

Fig. 5*a*. *Urnatopteris herbacea* Boulay sp.

Part of one side of an ultimate pinna with reduced pinnules. Enlarged seven times, from same specimen.

Fig. 6. *Sphyropteris obliqua* Marrat sp.

Fragments of two fertile pinnæ.

Locality.—Ravenhead, near St Helens, Lancashire.

Horizon.—Shales associated with Ravenhead Coal. Westphalian Series.

Natural size. Collected by the Rev. H. Higgins, now in Collection of Liverpool Museum.

Fig. 6*a*. *Sphyropteris obliqua* Marrat sp.

Pinna showing sterile and fertile pinnules from same specimen, enlarged three and a half times.

Fig. 6*b*. *Sphyropteris obliqua* Marrat sp.

The pinna given at fig. 6*a*, enlarged six times to show more distinctly the segmentation of the pinnules and mode of attachment of the fertile terminal expansion.

Fig. 6*c*. *Sphyropteris obliqua* Marrat sp.

Fertile terminal expansion more highly enlarged to show the sporangia arranged on oblique ridges. From same specimen.

Fig. 6*d*. *Sphyropteris obliqua* Marrat sp.

Sporangium enlarged fifty-three times to show terminal pore and elongated cells of the sporangial wall. From same specimen.

Fig. 7. *Sphyropteris obliqua* Marrat sp.

Part of a sterile pinna.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 2611.

Fig. 8. *Sphyropteris* cf. *tomentosa* Stur.

Fragments of fertile pinnæ.

Locality.—Chilvers Coton Clay Pit, Heath End, Nuneaton, Warwickshire.

Horizon.—Seven-foot Coal. Westphalian Series.

Natural size. Collected by Mr R. D. Vernon. Kidston Collection, No. 4815.

Fig. 9. *Sphyropteris* cf. *tomentosa* Stur.

Same specimen enlarged two times to show more distinctly the form of the "hammer-head-like" development of the fertile expansions.

Plate LXXXIV.

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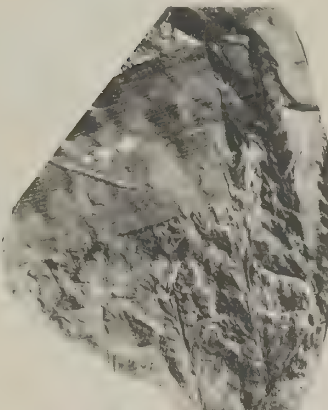

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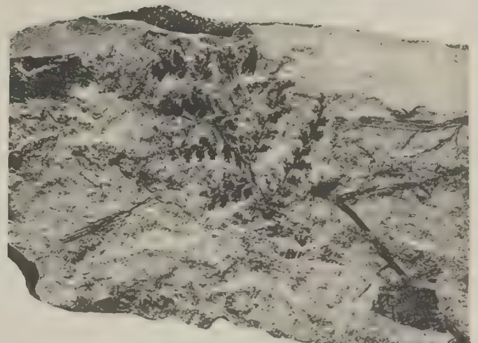

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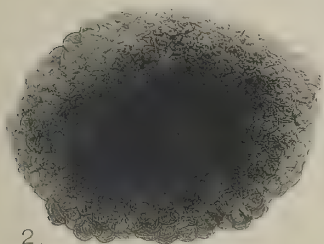

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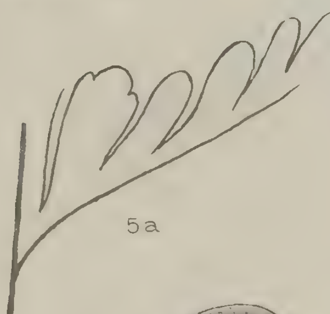

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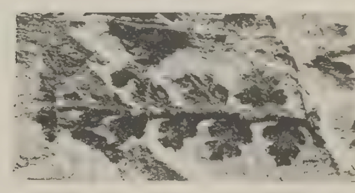

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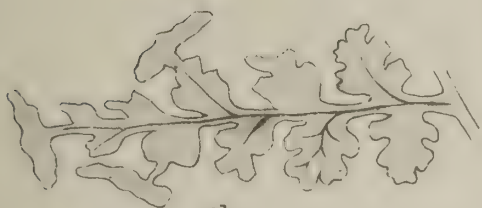

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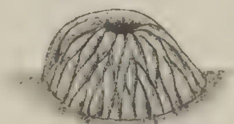

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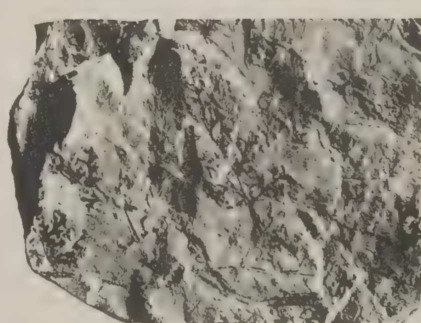

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6

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PLATE LXXXV.

Fig. 1. *Crossotheca Hœninghausi* Brongniart sp.

Portion of a frond showing dichotomy of rachis at *a*.

Locality.—Tullygarth Pit, near Clackmannan.

Horizon.— ? Lanarkian Series.

Natural size. Kidston Collection, No. 937.

Fig. 1*a*. *Crossotheca Hœninghausi* Brongniart sp.

Part of last specimen enlarged two times to show the form of the convex uncompressed pinnules.

Fig. 2. *Crossotheca Hœninghausi* Brongniart sp.

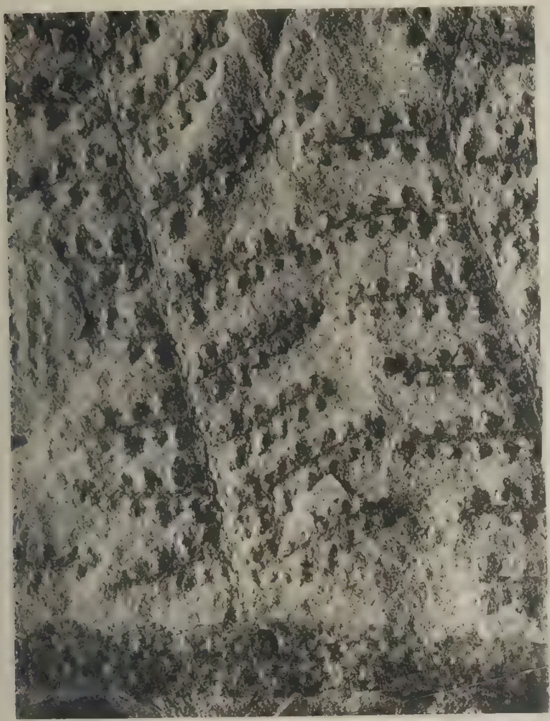
Portion of a frond.

Same locality and horizon as last.

Natural size. Kidston Collection, No. 936.

Fig. 2*a*. *Crossotheca Hœninghausi* Brongniart sp.

Part of last specimen, enlarged two times to show the form of the compressed and flattened pinnules.



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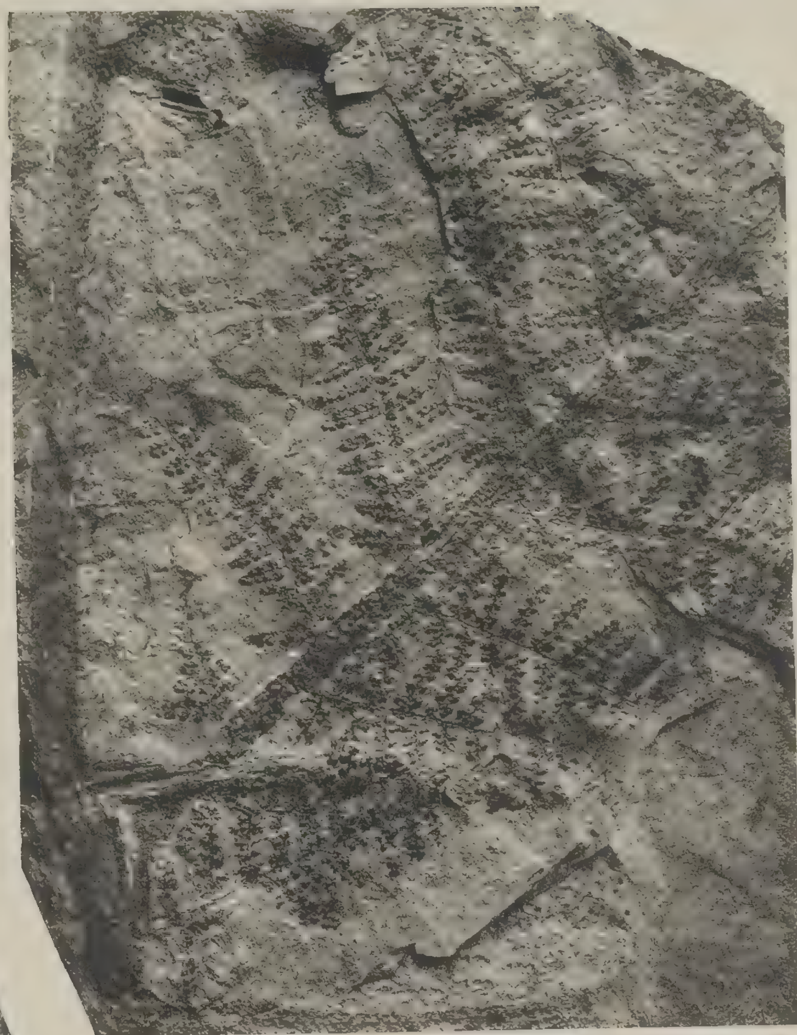

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PLATE LXXXVI.

Figs. 1–3. *Crossotheca Hœninghausi* Brongniart sp.

Fragments of pinnæ enlarged two times to show variation in the form of the pinnules.

Locality.—Clayscroft openwork, Coseley, near Dudley, South Staffordshire.

Horizon.—Ten-foot Ironstone Measures. Westphalian Series. Collection of Mr H. W. Hughes, F.G.S.

Fig. 4. *Crossotheca Hœninghausi* Brongniart sp.

Fragment of a stem showing the Lyginodendroid reticulations and the small central scars from which the spines have been removed.

Locality.—Whitehall Colliery, Rosewell, Midlothian.

Horizon.—Diamond (Rough) Seam.

Natural size. Kidston Collection, No. 3218.

Fig. 5. *Crossotheca Hœninghausi* Brongniart sp.

Fragment of a fertile pinna, showing sori.

Locality.—Clayscroft openwork, Coseley, near Dudley, South Staffordshire.

Horizon.—Ten-foot Ironstone Measures. Westphalian Series.

Enlarged two times. Collected by Mr J. T. Stobbs, F.G.S. Kidston Collection, No. 4722.

Fig. 6. *Crossotheca Hœninghausi* Brongniart sp.

Fragment of a fertile pinna. Same locality and horizon as last.

Natural size. Collection of Mr H. W. Hughes, F.G.S.

Fig. 6*a*. *Crossotheca Hœninghausi* Brongniart sp.

The last specimen enlarged three and a half times to show the sori.

Fig. 7. *Crossotheca Hœninghausi* Brongniart sp.

Fragment of a pinna showing sterile and fertile pinnules. Same locality and horizon.

Natural size. Collection of Mr H. W. Hughes, F.G.S.

Fig. 8. *Crossotheca Hœninghausi* Brongniart sp.

An ultimate pinnæ enlarged four times to show the spines on the rachis and segments of the flattened pinnules.

Locality.—Doulton's Clay Pit, Netherton, near Dudley, South Staffordshire.

Horizon.—Bed between Fireclay Coal and Bottom Coal. Westphalian Series. Kidston Collection, No. 940.

Fig. 9. *Crossotheca Hœninghausi* Brongniart sp.

Fragment of a pinna showing uncompressed convex pinnules.

Locality.—Tullygarth Pit, near Clackmannan.

Horizon.— ? Lanarkian Series.

Natural size. Kidston Collection, No. 938.

Fig. 10. *Crossotheca Hœninghausi* Brongniart sp.

Sterile pinna with ultimate pinnæ circinately coiled.

Locality.—Clayscroft openwork, Coseley, near Dudley, South Staffordshire.

Horizon.—Ten-foot Ironstone Measures. Westphalian Series.

Enlarged two times. Collection of Mr H. W. Hughes, F.G.S.

Fig. 11. *Crossotheca Hœninghausi* Brongniart sp.

Fragment of a fertile pinna. Same locality and horizon as last.

Enlarged two times. Collection of Mr H. W. Hughes, F.G.S.

Fig. 11*a*. *Crossotheca Hœninghausi* Brongniart sp.

Small part of last specimen, enlarged four times.

Fig. 12. *Crossotheca Hœninghausi* Brongniart sp.

Part of a fertile pinna, enlarged two times to show the sori in an immature condition before the microsporangia spread outward.

Same locality and horizon as last specimen. Collection of Mr H. W. Hughes, F.G.S.

Fig. 13. *Crossotheca Hœninghausi* Brongniart sp.

Sorus exhibiting the individual microsporangia. Same locality and horizon as last.

Enlarged four times. Collection of Mr H. W. Hughes, F.G.S.

Palaeontology. Vol. II. 1923. Plate LXXXVI.

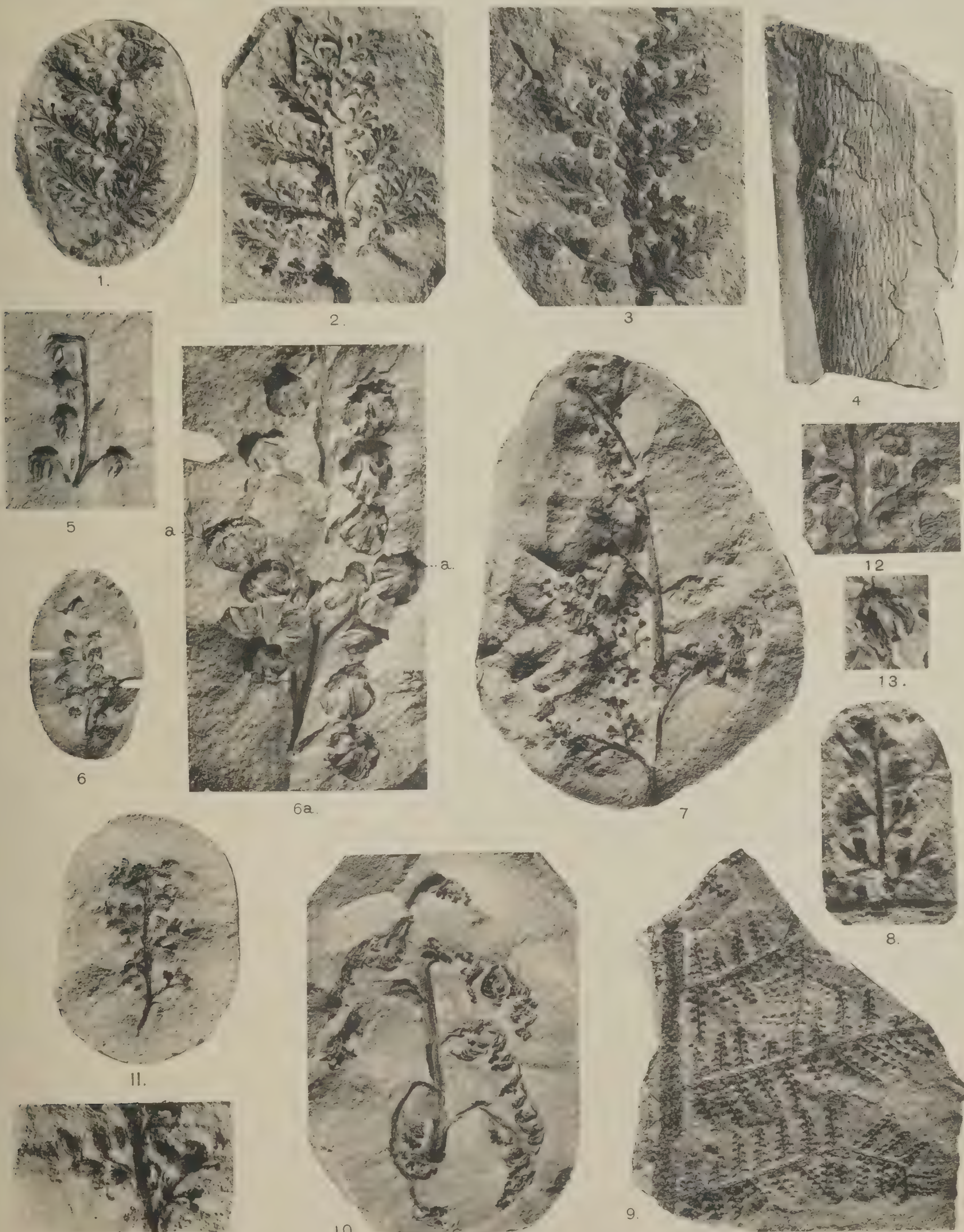

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PLATE LXXXVII.

Fig. 1. *Crossotheca Crepini* Zeiller.
Fragments of penultimate pinnæ.
Locality.—Hamstead Colliery, Great Barr, near Birmingham.
Horizon.—Blue Measures, 6 feet above Brooch Coal. Westphalian Series.
Natural size. Collected by Mr HENRY INSLEY. Kidston Collection, No. 4643.

Fig. 1*a*. *Crossotheca Crepini* Zeiller.
Some ultimate pinnæ of last specimen, enlarged two times to show form of pinnules.

Fig. 2. *Crossotheca Crepini* Zeiller.
Fragments of penultimate pinnæ.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. R. BARKER. Kidston Collection, No. 5845.

Fig. 3. *Crossotheca sagittata* Lesquereux sp.
Small fragment of a fertile pinna.
Locality.—Gelli-deg level, Maes-y-Cwmmer, Monmouthshire.
Horizon.—Mynyddislwyn Seam. Radstockian Series.
Natural size. Collection of Geological Survey, London. No. 32388.

Fig. 4. *Crossotheca Hœninghausi* Brongniart sp.
Fragments of pinnæ, one dichotomous, showing a small form of pinnule.
Locality.—Chopwell, 2½ miles north-east of Ebchester, County of Durham.
Horizon.—Three-quarter Coal. Westphalian Series.
Enlarged two times. Collected by Mr P. CHARLTON. Kidston Collection, No. 5174.

Figs. 5–10. *Crossotheca Hœninghausi* Brongniart sp.
Microspores enlarged five hundred times.
Locality.—Clayscroft openwork, Coseley, near Dudley, South Staffordshire.
Horizon.—Ten-foot Ironstone Measures. Westphalian Series.

MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN

Palaeontology Vol. II. 1923. Plate LXXXVII.

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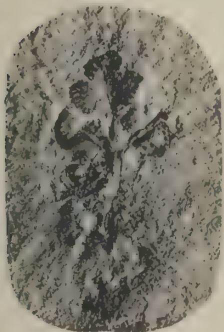

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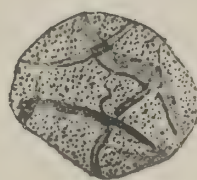

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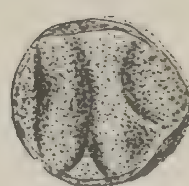

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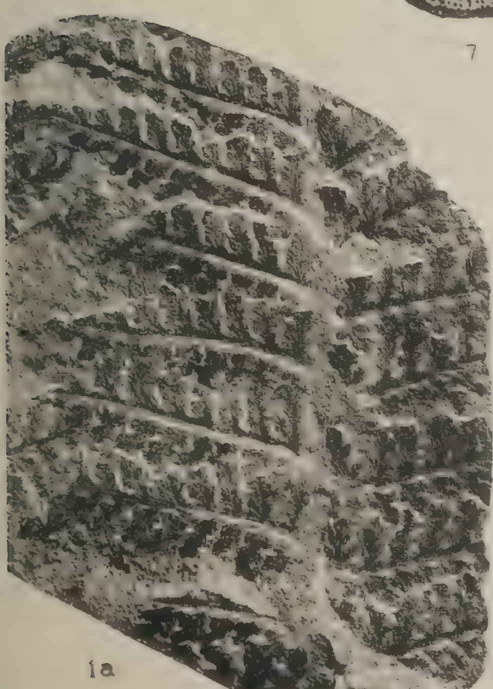

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PLATE LXXXVIII.

Fig. 1. *Crossotheca Hughesiana* Kidston.

Portion of a fertile pinna.

Locality.—Clayscroft openwork, Coseley, near Dudley, South Staffordshire.

Horizon.—Ten-foot Ironstone Measures. Westphalian Series.

Natural size. All the specimens figured in this plate are in the Collection of Mr H. W. Hughes, F.G.S.

Fig. 2. *Crossotheca Hughesiana* Kidston.

Part of an immature fertile pinna showing the impression of the upper surface of the pinnules. Same locality and horizon.

Natural size.

Fig. 2*a*. *Crossotheca Hughesiana* Kidston.

Impression of the same specimen as seen on the other half of the nodule showing the microsporangia bent in towards the centre where their apices meet.

Fig. 2*b*. *Crossotheca Hughesiana* Kidston.

Ultimate pinna of specimen seen at 2*a*, enlarged two times.

Fig. 2*c*. *Crossotheca Hughesiana* Kidston.

Portion of an ultimate pinna from specimen given at fig. 2, enlarged two times.

Fig. 3. *Crossotheca Hughesiana* Kidston.

Upper portion of a fertile ultimate pinna showing the microsporangia bent inwards and their apices meeting in the centre; also showing a side view of the thick fleshy limb of the pinnule to which they are attached. Same locality and horizon.

Enlarged two times.

Fig. 4. *Crossotheca Hughesiana* Kidston.

Part of an immature fertile pinna. Same locality and horizon.

Natural size.

Fig. 5. *Crossotheca Hughesiana* Kidston.

Part of an ultimate fertile pinna showing the mature sporangia separated and spreading outwards. The line of separation of the two halves of the nodule has passed longitudinally through many of the sporangia, which thus exhibit the inner surface of their adaxial wall with the longitudinal slit by which dehiscence took place.

Same locality and horizon.

Enlarged two times.

Fig. 6. *Crossotheca Hughesiana* Kidston.

Part of an immature pinna. Same locality and horizon.

Natural size.

Fig. 7. *Crossotheca Hughesiana* Kidston.

A few mature fertile pinnules, enlarged two times to show falcate form of microsporangia. Same locality and horizon.

Fig. 8. *Crossotheca Hughesiana* Kidston.

Cavity left in the matrix which was originally occupied by a sorus now removed through decay. The radiating hollows mark the position originally occupied by the microsporangia; the ridges between them the infilling matrix.

Same locality and horizon.

Enlarged two times.

Fig. 9. *Crossotheca Hughesiana* Kidston.

Fertile ultimate pinna showing the attachment of the pedicel to the limb of the pinnule and the pendent microsporangia. Same locality and horizon.

Fig. 10. *Crossotheca Hughesiana* Kidston.

Portion of a fertile ultimate pinna showing the cavities in the matrix originally occupied by the microsporangia. Same locality and horizon.

Enlarged two times.

Fig. 10*a*. *Crossotheca Hughesiana* Kidston.

Other half of the same nodule showing the impression of the upper surface of the pinnules and their attachment to the pedicel.

Enlarged two times.

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PLATE LXXXIX.

Fig. 1. *Crossotheca Schatzlarensis* Stur sp.

Fragment of a sterile pinna.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1957.

Fig. 1*a*. *Crossotheca Schatzlarensis* Stur sp.

Two pinnules from last specimen, enlarged three and a half times to show their segmentation and nervation.

Fig. 2. *Crossotheca Schatzlarensis* Stur sp.

Fragment of a sterile primary (?) pinna.

Locality.—Low Moor, Yorkshire.

Horizon.—White Rake Bed. Westphalian Series.

Natural size. Kidston Collection, No. 1405.

Fig. 3. *Crossotheca Schatzlarensis* Stur sp.

Fragments of fertile pinnæ.

Locality.—East Gawber Colliery, near Barnsley, Yorkshire.

Horizon.—Shale over Barnsley Coal. Westphalian Series.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 899.

Fig. 4. *Crossotheca Schatzlarensis* Stur sp.

Fragment of a fertile pinna. Same locality and horizon as last.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 900.

Fig. 5. *Crossotheca Schatzlarensis* Stur sp.

The two sori, lettered *a* on fig. 3, enlarged six and a half times to show arrangement of the microsporangia.

Fig. 6. *Crossotheca Schatzlarensis* Stur sp.

Two microsporangia from specimen given at fig. 4, indicated by the letter *a*, enlarged six and a half times to show form of microsporangium at *a*, and their arrangement on the limb of the pinnule.

Fig. 7. *Crossotheca Schatzlarensis* Stur sp.

Immature sorus enlarged about four times to show attachment of pedicel to the limb of the pinnule.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Collected by Mr W. Hemingway. Kidston Collection, No. 2037.

Fig. 8. *Crossotheca Schatzlarensis* Stur sp.

Immature sorus enlarged about four times to show attachment of pedicel.

Same locality and horizon as last.

Collected by Mr W. Hemingway. Kidston Collection, No. 2040.

Fig. 9. *Crossotheca communis* Lesquereux sp.

Portions of two primary (?) pinnæ.

Locality.—Lane End, Fenton, Staffordshire.

Horizon.—Below Moss Coal. Westphalian Series.

Natural size. Collected by the late Dr W. Hind. Kidston Collection, No. 2081.

Figs. 9*a*–*b*. *Crossotheca communis* Lesquereux sp.

Tertiary pinnæ from last specimen, enlarged four and a half times to show form and nervation.

Fig. 9*c*. *Crossotheca communis* Lesquereux sp.

Pinnule from same specimen, enlarged to show villose surface.

Fig. 10. *Crossotheca communis* Lesquereux sp.

Fragments of fertile pinnæ. Same locality and horizon.

Natural size. Collected by the late Dr W. Hind. Kidston Collection, No. 2083.

Fig. 10*a*. *Crossotheca communis* Lesquereux sp.

Fertile ultimate pinna from last specimen, enlarged four times.

Plate LXXXIX.

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PLATE XC.

Fig. 1. *Crossotheca pinnatifida* Gutbier sp.
Fragments of secondary pinnæ from the lower portion of the frond. The upper end of the fossil and the direction of the axis is indicated by the arrow.
Locality.—Radstock, Somersetshire.
Horizon.—Radstock Group, Radstockian Series.
Natural size. Kidston Collection, No. 448.

Fig. 1*a*. *Crossotheca pinnatifida* Gutbier sp.
Ultimate pinna from last specimen, enlarged three and a half times.

Fig. 2. *Crossotheca pinnatifida* Gutbier sp.
Upper portion of primary pinna.
Locality.—Ludlow's Pit, Radstock, Somersetshire.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 449.

Fig. 3. *Crossotheca pinnatifida* Gutbier sp.
Upper portion of a primary pinna.
Locality.—Camerton, Somersetshire.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 3827.

Fig. 3*a*. *Crossotheca pinnatifida* Gutbier sp.
Pinnules from last specimen, enlarged three and a half times to show their form and nervation.

Fig. 4. *Crossotheca pinnatifida* Gutbier sp.
Fragment of a fertile pinna showing the sori.
From Potonié. "Flora des Rothliegenden von Thüringen" (*Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft 9), pl. xviii, fig. 9*a*.

Fig. 5. *Crossotheca pinnatifida* Gutbier sp.
Two pinnules enlarged two times to show their decurrent attachment to the rachis.
Locality.—Ludlow's Pit, Radstock, Somersetshire.
Horizon.—Radstock Group. Radstockian Series.
Kidston Collection, No. 450.

Plate XC.

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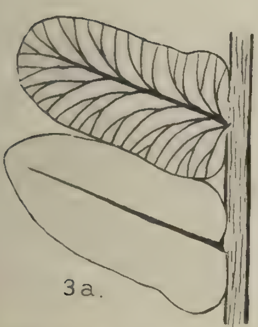

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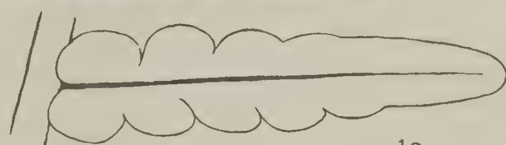

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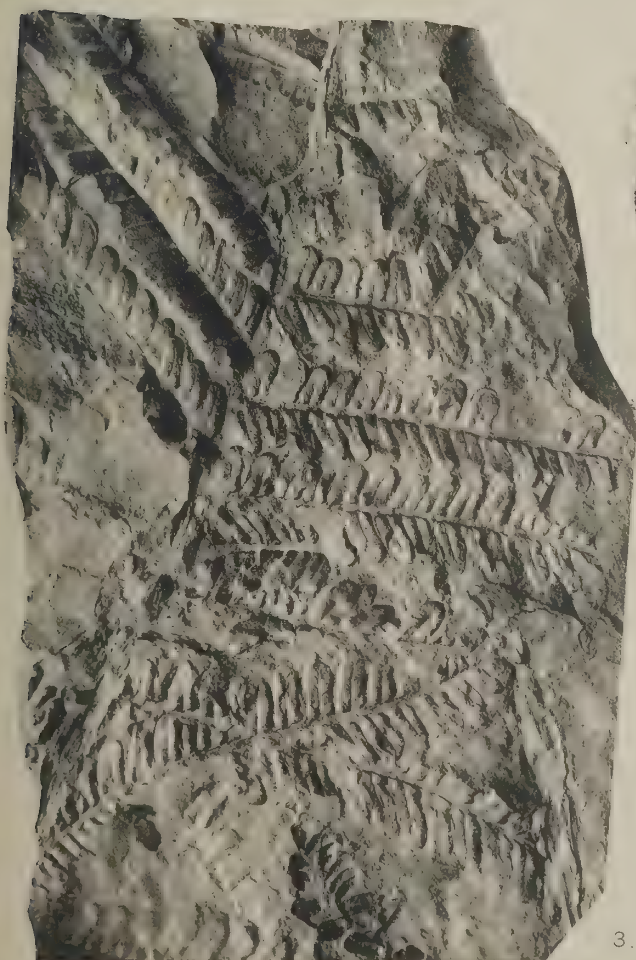

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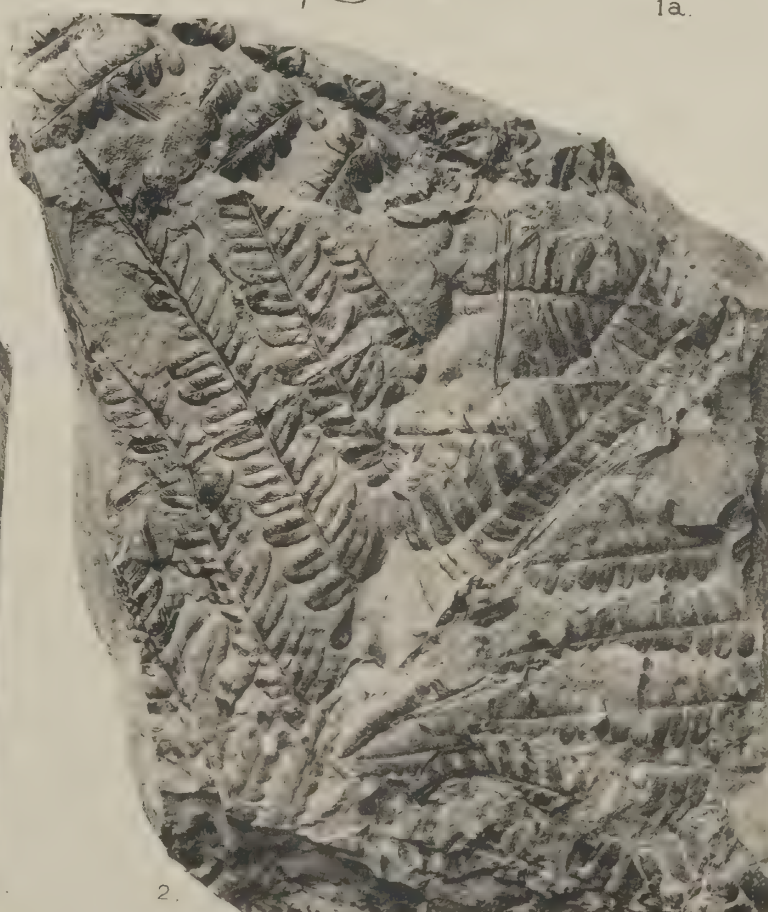

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PLATE XCI.

Fig. 1. *Crossotheca Boulayi* Zeiller.
Fragment of pinna.
Locality.—Cambrian Colliery, Clydach Vale, Rhondda Valley, Glamorganshire.
Horizon.—No. 2 Rhondda Seam. Staffordian Series.
Natural size. Collected by Mr D. Davies, F.G.S. Kidston Collection, No. 4191.

Fig. 2. *Crossotheca Boulayi* Zeiller.
Fragment of a pinna.
Same locality and horizon.
Natural size. Collected by Mr D. Davies, F.G.S. Kidston Collection, No. 4157.

Fig. 3. *Crossotheca Boulayi* Zeiller.
Fragments of pinnæ.
Same locality and horizon.
Natural size. Collected by Mr D. Davies, F.G.S. Kidston Collection, No. 4159.

Fig. 4. *Crossotheca Boulayi* Zeiller.
Terminal portion of a pinna.
Same locality and horizon.
Natural size. Collected by Mr D. Davies, F.G.S. Kidston Collection, No. 4192.

Fig. 5. *Crossotheca Boulayi* Zeiller.
Fertile pinna.
Same locality and horizon.
Natural size. Collected by Mr D. Davies, F.G.S. Kidston Collection, No. 4190.

Fig. 6. *Crossotheca Boulayi* Zeiller.
Fertile pinnules.
Locality.—Standard Colliery, Ynyshir, Glamorganshire.
Horizon.—No. 2 Rhondda Seam. Staffordian Series.
Natural size. Collected by Mr R. Weed. Kidston Collection, No. 4038.

Fig. 6*a*. *Crossotheca Boulayi* Zeiller.
Same specimen as last, enlarged two times to show microsporangia.

Fig. 7. *Crossotheca Boulayi* Zeiller.
Pinnules enlarged two times ; to show the hastate form of the limb.
Locality.—Cambrian Colliery, Clydach Vale, Rhondda Valley, Glamorganshire.
Horizon.—No. 2 Rhondda Seam. Staffordian Series.
Collected by Mr D. Davies, F.G.S. Kidston Collection, No. 4156.

Plate XCI.

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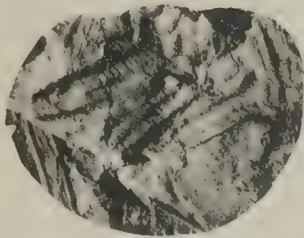

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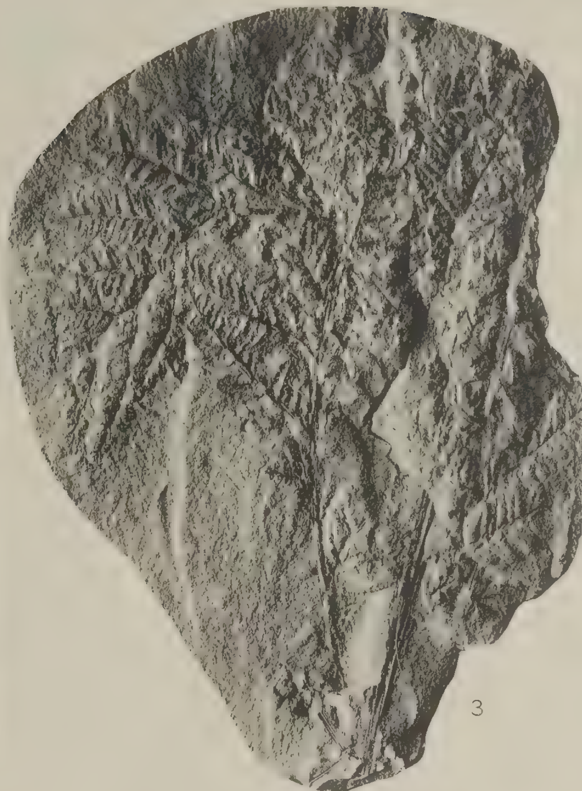

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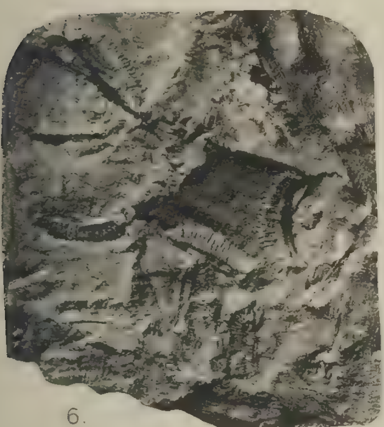

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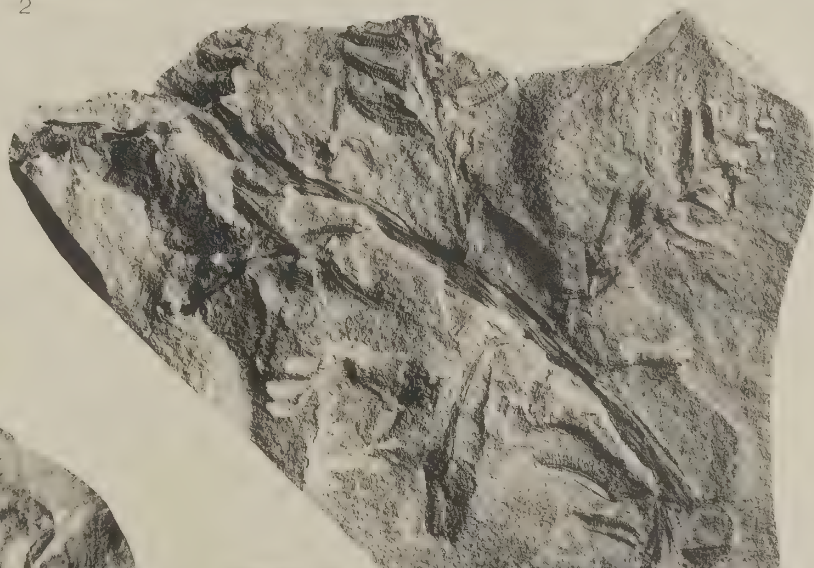

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MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

PALÆONTOLOGY.

VOL. II. PART 5.
PAGES 377–522; PLATES XCII–CXXII.

FOSSIL PLANTS

OF THE

CARBONIFEROUS ROCKS OF GREAT BRITAIN.

BY

ROBERT KIDSTON, LL.D., D.Sc., F.R.S. L. & E., F.G.S.

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INDEX TO SPECIES DESCRIBED IN PART 5.

LIST OF TEXT-FIGURES.

Genus **Cyclotheca** Kidston.

1888. *Cyclotheca* Kidston, "Fructification of two Coal-Measure Ferns," *Ann. and Mag. Nat. Hist.*, ser. 6, vol. ii, p. 26.

1891. *Cyclotheca* Kidston, "Fructification . . . of Carboniferous Ferns," *Trans. Geol. Soc. Glasgow*, vol. ix, p. 27.

Description.—Sporangia exannulate, circular in outline, free, sessile, and arranged on the pinnule in two parallel rows, one row on each side of a midrib.

Remarks.—The pinnules have been long and very narrow, and the sporangia are placed very close to the midrib. No lateral veins are shown on the slight stain on the matrix, which forms a border to the sporangia and appears to represent the width of the pinnule. It is most probable that a series of lateral veinlets, which have not been preserved, extended from the midrib to the margin of the pinnule, and that the sporangia were situated on them, close to the midrib.

Cyclotheca biseriata Kidston.

Plate XCVIII, fig. 7; Plate XCIX, figs. 3–7.

1888. *Cyclotheca biseriata* Kidston, "Fructification of two Coal-Measure Ferns," *Proc. Roy. Phys. Soc. Edin.*, vol. ix, p. 515, pl. xxi, figs. 10–12.

1888. *Cyclotheca biseriata* Kidston, *Ann. and Mag. Nat. Hist.*, p. 26, pl. i, figs. 10–12.

1891. *Cyclotheca biseriata* Kidston, *Trans. Geol. Soc. Glasgow*, vol. ix, pl. ii, figs. 27A, 27B.

Description.—Pinnules narrow-linear, about 3 mm. in breadth, 2·5 cm. or more in length, bearing two rows of sporangia placed close to each other and probably forming a row on each side of a midrib. Sporangia exannulate, circular, about 0·60 mm. in diameter, with compact walls formed of small cells. Spores very numerous, circular in outline, surface smooth, with triradiate ridge, and have a diameter of 50 μ to 54 μ.

Remarks.—The largest fragment of this fructification, which forms the type of the species, is given natural size at fig. 3, Pl. XCIX. It shows several somewhat displaced, long, linear pinnules springing from a rachis, of which a small part is seen in the centre of the figure. Two fragments of pinnæ are further given at figs. 4, 5. The two rows of sporangia are placed very close to each other, and the sporangia of one row usually alternate with those of the other row, as seen at fig. 6. Although closely placed to each other laterally they do not touch, and always preserve their circular outline. Some sporangia enlarged twenty times are given at fig. 6, and the spore-contents of one of these, enlarged fifty times, is seen at fig. 7, while a few of the spores are enlarged two hundred and fifty times at fig. 7, Pl. XCVIII. Some of the spores exhibit a central body which probably represents the contracted cell-contents.

A slight band-like stain on the matrix, which can be faintly seen on figs. 4 and 5, Pl. XCIX, extends for about 1 mm. beyond the sporangia, and probably represents

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the limb of the pinnule, but it shows no indication of lateral veinlets. These and a median vein were most probably present originally in the pinnules, but have now disappeared, and the thick leathery-walled sporangia alone have been able to resist decay.

The only genus with similar long, narrow pinnules which occurs in the Lanarkian Series, and with which *Cyclotheca biseriata* might be compared, is *Alethopteris*. The similarity in the form of the pinnules suggests the possibility that, if the limb of the fertile pinnules had undergone reduction, *Cyclotheca biseriata* may be the microsporangial condition of such a species as *Alethopteris decurrens* Artis sp., or even of *Alethopteris lonchitica* Schlotheim sp. Our present knowledge of the plant, however, does not enable us to determine definitely the relationship of *Cyclotheca* to *Alethopteris*.

The specimens were collected by Mr P. Jack, and the type is preserved in the "Dunlop Collection," Pittencrieff Museum, Dunfermline.

Distribution.—Very rare, and known from only one locality.

LANARKIAN SERIES.

Lanarkshire Coalfield.

Horizon: Kiltongue Coal. *Locality:* Ellismuir, Baillieston (P. Jack).

Genus **Unatheca** Kidston.

1891. *Unatheca* Kidston, "Fructification . . . of Carboniferous Ferns," *Trans. Geol. Soc. Glasgow*, vol. ix, p. 32.

1888. *Ptychocarpus* Kidston (*non* Weiss), "Foss. Flora, Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 350.

Description.—Sporangia alternate, exannulate, oval-oblong, smooth, contracted into a pedicel at base, attaining a length of 2 mm., opening by a longitudinal cleft and forming a row on each side of the rachis.

Remarks.—The specimen which forms the type of this genus was originally placed in *Ptychocarpus* Weiss,* but with considerable reservation. Subsequent investigation has shown that the fructification of our plant differs essentially from *Ptychocarpus*, where the sporangia, to the number of usually five to eight, are united together to form a synangium, whereas in *Unatheca* each sporangium is free. One can frequently observe that the single sporangium of *Unatheca* is surrounded by a narrow stain on the matrix, as shown at figs. 3*a*, 3*b*, Pl. CIV, and this may indicate the margin of a narrow, surrounding limb of the pinnule or the pinnule-segment on which it is placed. Such is the probable structure of the fructification. There is, however, the possibility that this appearance may be due to some other cause, and that the fructification consisted of free sporangia unassociated with any pinnule limb.

The sporangia open by a longitudinal cleft which extends almost throughout

* "Foss. Flora jüngst. Steink. u. Rothl. in Saar-Rhein-Gebiete," p. 94.

their length, and only terminates at a short distance from each extremity, as seen at fig. 3*b*. Their surface shows none of the transverse ridges so characteristic of the sporangia of *Radstockia*, nor are the sporangia developed in pairs as in that genus.

There is no satisfactory evidence by which one can decide whether *Unatheca* should be classed with the ferns or with the pteridosperms.

Distribution.—Very rare. Only recorded from the Radstock Group.

Unatheca oblonga Kidston.

Plate CIV, figs. 3, 3*a*, 3*b*.

1888. *Ptychocarpus oblongus* Kidston, "Foss. Flora, Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 350, pl. xx, fig. 2.

1891. *Unatheca oblonga* Kidston, "Fructification . . . of Carboniferous Ferns," *Trans. Geol. Soc. Glasgow*, vol. ix, p. 32, pl. iii, fig. 33.

Description.—Frond at least tripinnate, rachis stout, punctate. Penultimate pinnæ alternate, narrow-oblong, with sides straight till near the apex, where they converge and end in a point. Ultimate pinnæ of similar form, the larger bearing four or five pairs of alternate sporangia and one in a terminal position. Sporangia elongate-oval, exannulate, with a smooth outer surface, and opening by a longitudinal split which passes down the middle and extends almost the whole length of the sporangium, terminating only a short distance from its two extremities.

The sporangia are bordered by a narrow stain, which may represent the margin of the limb of the pinnule or segment of a pinnule on which they are borne.

Remarks.—The specimen is shown natural size at fig. 3, Pl. CIV. It is difficult to determine whether the structures described above as ultimate pinnæ really are such, or whether they are pinnules in which the segments or lobes are free from each other. The view adopted here is that each sporangium occupies a small and separate pinnule.

The structure of the individual sporangia seems clear, and on some of them the cleft by which dehiscence has taken place is distinctly open. This is especially well seen on a small piece in my collection, No. 257, which was removed from the face of the specimen given at fig. 3.

One cannot be quite certain how to regard the dark border which is seen to surround the sporangia as illustrated at figs. 3*a* and 3*b*. My view is that it most probably represents the margin of the limb of the small pinnule, or segment of the pinnule (according to the manner of interpreting the whole structure), on which the sporangia were placed. That the structures themselves were firm-walled exannulate sporangia that opened by a longitudinal cleft is clearly seen, but whether these were borne on reduced small pinnules or on segments of larger-lobed pinnules cannot be satisfactorily determined, though I incline to the former view.

The systematic position of *Unatheca oblonga* must for the present be left an open question.

Distribution.—So far as I know, the only two records of *Unatheca oblonga* are from rocks belonging to the Radstock Group.

RADSTOCKIAN SERIES.

RADSTOCK GROUP.

Horizon: ?. *Locality:* Camerton, 2 miles north of Radstock, Somerset.

Horizon: ?. *Locality:* Timsbury, 2½ miles N.N.W. of Radstock, Somerset (E. A. N. ARBER; in Sedgwick Museum, Cambridge).

Genus **Dactylotheca** Zeiller.

1883. *Dactylotheca* Zeiller, "Fructifications de fougères du terrain houiller," *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, p. 184.
1888. *Dactylotheca* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 30.
1891. *Dactylotheca* Kidston, "Fructification . . . of Carboniferous Ferns," *Trans. Geol. Soc. Glasgow*, vol. ix, pt. i, p. 27.
1883. *Senftenbergia* Stur (*non* Corda) (*pars*), "Morph. u. System. d. Culm-u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien.*, Band lxxxviii, Abt. 1, p. 33.
1885. *Senftenbergia* Stur (*non* Corda) (*pars*), "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 64.

Description.—Sporangia exannulate, ovoid, free, placed lengthwise on the lateral veinlets a short distance from their base, with their apices directed to the margin of the pinnule. Walls formed of cells elongated in the direction of the greater axis, with (on *Dactylotheca plumosa* Artis sp.) a vertical band of narrower cells which form a stomium where, at maturity, the sporangia ruptured for the dissemination of the spores. The sporangia are from 0·50 mm. to 0·75 mm. in length, and have a breadth of from 0·20 mm. to 0·25 mm.

Remarks.—The fertile pinnules undergo very little reduction of the limb, and the sporangia frequently cover a considerable portion of the under surface of the pinnules. They differ from those of *Renaultia* in their more elongated form and in the mode of attachment to the veinlets.

The few species at present known to belong to the genus have a pecopteroid type of sterile pinnule.

In the genus *Senftenbergia* Corda,* in which STUR placed certain Carboniferous ferns with a fructification like that of *Dactylotheca*, the sporangia have a very prominent apical annulus, while those of *Dactylotheca* are exannulate.

The systematic position of the genus is not definitely determined, but it is more probable that it belongs to the Pteridosperms rather than the Filices.

Distribution.—The genus *Dactylotheca* occurs both in Lower and Upper Carboniferous Rocks.

* "Flora d. Vorwelt," p. 91, pl. lxvii, figs. 1–6, 1845.

Dactylotheca plumosa Artis sp.

Plate XCII ; Plate XCIII ; Plate XCIV, figs. 1–3 ; Plate XCV, figs. 1–3 ; Plate XCVI, figs. 2, 3 ; Plate CX, figs. 1, 2 ; Plate CXII, figs. 2, 2*a* ; text-fig. 32.

1825. *Filicites plumosus* Artis, " Antediluvian Phytology," p. 17, pl. xvii.
1828. *Pecopteris plumosa* Brongniart, " Prodrome," p. 58.
1836. *Pecopteris plumosa* Brongniart, " Hist. des végét. foss.," vol. i, p. 348, pl. cxxi ; pl. cxxii.
1869. *Pecopteris plumosa* Roehl, " Foss. Flora d. Steink. Form. Westphalens," *Palaeontographica*, Band xviii, p. 88, pl. xxvii, fig. 4.
1903. *Pecopteris plumosa* Potonié, " Phys. u. Morphologie d. foss. Farn-Aphlebien," *Bericht Deutsch. Botan. Gesellsch.*, Band xxi, p. 153, pl. viii.
1907. *Pecopteris plumosa* Sterzel, " Karbon-u-Rothl. im Grossherzog. Baden," *Mitt. Badischen geol. Landesanst.*, Band v, Heft 2, p. 496, pl. xxvii, figs. 1, 2.
1912. *Pecopteris plumosa* Potonié, " Grundlinien d. Pflanzen-Morph.," p. 16, fig. 12 ; p. 18, fig. 14 A, B.
1914. *Pecopteris plumosa* Stopes, " Fern Ledges," *Canada, Dept. of Mines, Geol. Survey*, Mem. No. 41, p. 44, pl. xiii, figs. 27, 28, 29, text-fig. 7.
1877. *Senftenbergia plumosa* Stur, " Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 293.
1883. *Senftenbergia plumosa* Stur, " Morph. u. Syst. d. Culm- u. Carbonfarne," *Sitzungsber. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1.
1885. *Senftenbergia plumosa* Stur, " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 92, pl. li, figs. 1–3.
1914. *Senftenbergia plumosa* Bureau, " Bassin de la Basse Loire," fasc. 2, " Flores fossiles," *Études Gîtes Min. France*, p. 94, pl. viii, figs. 1–4 ; pl. xxviii, figs. 3, 4 (*refs. in part*).
1886. *Dactylotheca plumosa* Kidston, " Catal. Palæoz. Plants in British Museum," p. 128.
1896. *Dactylotheca plumosa* Kidston (*pars*), " Fossil Flora, Yorkshire Coalfield," *Trans. Roy. Soc. Edin.*, vol. xxxviii, p. 205, pl. i, figs. 1–3 (*non* fig. 4) ; pl. ii ; pl. iii.
1899. *Pecopteris* (*Dactylotheca*) *plumosa* Zeiller, " Flore foss. bassin houil. d'Héraclée," *Mém. Soc. géol. France, Paléont.*, No. 21, p. 34.
1901. *Dactylotheca plumosa* Kidston, " Flora of the Carboniferous Period," *Proc. Yorks. Geol. and Polytech. Soc.*, vol. xiv, pt. 2, pp. 194, 209, 217, pl. xxvii, fig. 1 ; pl. xxxi, figs. 1–4.
1907. *Pecopteris* (*Dactylotheca*) *plumosa* Zalessky, *Mém. Com. géol.*, N.S., livr. 33, p. 63, pl. ii, fig. 1.
1910. *Pecopteris* (*Dactylotheca*) *plumosa* Schmitz in Renier, " Documents paléont. terr. houil.," pls. lxxxvii, lxxxviii.
1912. *Pecopteris* (*Dactylotheca*) *plumosa* Arber, *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 2, p. 332, pl. xxxix, fig. 14.
1913. *Pecopteris* (*Dactylotheca*) *plumosa* Gothan, " Oberschlesische Steinkohlenflora," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Band lxxv, Teil i, p. 151, pl. xxxiii, figs. 1, 2, 5, text-fig. 10.
1828. *Pecopteris triangularis* Brongniart, " Prodrome," p. 58.
1834. *Sphenopteris crenata* Lindley and Hutton, " Fossil Flora," p. 57, pl. c ; pl. ci.
1869. *Sphenopteris* (*Cheil.*) *crenata* Schimper, " Traité de paléont. végét.," vol. i, p. 379.
1890. *Sphenopteris crenata* Kidston, *Trans. Yorks. Nat. Union*, pt. 14, p. 30.
1836. *Cheilanthites crenatus* Göppert, " Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 248.
1883. *Senftenbergia crenata* Stur, " Morph. u. Syst. d. Culm- u. Carbonfarne " (*op. supra cit.*), p. 44.
1885. *Senftenbergia crenata* Stur, " Carbon-Flora d. Schatzlarer Schichten " (*op. supra cit.*), p. 72, pl. xlv, figs. 1, 2, 3 ; pl. xlvi, figs. 1, 2, 3.
1834. *Schizopteris adnascens* Lindley and Hutton, " Fossil Flora," vol. i, p. 58, pl. c ; pl. ci.
1836. *Trichomanites adnascens* Göppert, " Syst. fil. foss.," p. 266.
1838. *Aphlebia adnascens* Presl in Sternberg, " Versuch," vol. ii, fasc. vii, viii, p. 113.

1869. *Rhacophyllum adnascens* Schimper, "Traité de paléont. végét.," vol. i, p. 686, pl. xlviii, figs. 1, 2, 7.
1884. *Rhacophyllum adnascens* Heyer, *Botan. Centralblatt*, Band xix, p. 277.
1832. *Sphenopteris caudata* Lindley and Hutton, "Fossil Flora," vol. i, p. 137, pl. xlviii; vol. ii, p. 157, pl. cxxxviii.
1836. *Aspidites caudatus* Göppert, "Syst. fil. foss.," p. 363.
1845. *Pecopteris caudata* Unger, "Synop. plant. foss.," p. 97.
1834. *Pecopteris serra* Lindley and Hutton, "Foss. Flora," vol. ii, p. 71, pl. cvii.
1838. *Pecopteris serra* Sternberg, "Versuch," vol. ii, fasc. vii, viii, p. 159.
1869. *Pecopteris* (*Cyath.*) *serra* Schimper, "Traité de paléont. végét.," vol. i, p. 504.
1877. *Pecopteris serra* (?) Lebour, "Illus. of Fossil Plants," p. 47, pl. xxiii.
1836. *Alethopteris serra* Göppert, "Syst. fil. foss.," p. 302.
1828. *Pecopteris dentata* Brongniart, "Prodrome," p. 58.
1834. *Pecopteris dentata* Brongniart, "Hist. des végét. foss.," p. 346, pl. cxxiii; pl. cxxiv.
1835. *Pecopteris dentata* Lindley and Hutton, "Fossil Flora," vol. ii, p. 201, pl. cliv.
1838. *Pecopteris dentata* Sternberg, "Versuch," vol. ii, fasc. vii, viii, p. 152.
1869. *Pecopteris dentata* Schimper, "Traité de paléont. végét.," vol. i, p. 508.
1879. *Pecopteris dentata* Lesquereux, "Coal Flora," vol. i, p. 240 (*non* pl. xliv, fig. 4).
1880. *Pecopteris dentata* Zeiller, "Végét. foss. du terr. houil.," p. 87, pl. clxviii, figs. 3, 4.
1882. *Pecopteris dentata* Zeiller, "Flore houil. des Asturies," *Mém. Soc. géol. du Nord*, vol. i, no. 3, p. 14.
1883. *Pecopteris dentata* Renault, "Cours de botan. foss.," vol. iii, p. 121, figs. 4, 5.
1893. Cf. *Pecopteris dentata* var. *saxonica* Sterzel, "Flora d. Rothl. im Plauenschen Grunde," *Abhandl. k. Sächs. Gesellsch. Wiss.*, Band xix, p. 37, pl. v, figs. 1–6.
1899. *Pecopteris dentata* Potonié, "Lehrb. d. Pflanzenpal.," p. 108, fig. 96.
1899. *Pecopteris dentata* Hofmann and Ryba, "Leitpflanzen," p. 53, pl. vii, figs. 1, 2.
1836. *Cyatheites dentatus* Göppert, "Syst. fil. foss.," p. 325.
1855. *Cyatheites dentatus* Geinitz (*pars*), "Verstein. d. Steink. Form. in Sachsen," p. 26, pl. xxix, figs. 10–12; pl. xxx, fig. 2.
1869. *Cyatheites dentatus* Roehl, "Foss. Flora d. Steink. Form. Westphalens," *Palaeontographica*, Band xviii, p. 87 (? pl. xxvii, fig. 6).
1869. *Cyathocarpus dentatus* Weiss, "Foss. Flora d. jüngst. Steink. u. Rothl.," p. 86.
1877. *Prepecopteris* (*Pecopteris*) *dentata* Grand'Eury, "Flore carbon. du Départ. de la Loire," *Mém. Acad. Sci., Paris*, xxiv, no. 1, p. 63.
1877. *Senftenbergia dentata* Stur, "Culm Flora," Heft 2, p. 293.
1883. *Dactylotheca dentata* Zeiller, *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, pp. 184, 207, pl. ix, figs. 12–15.
1883. *Dactylotheca dentata* Zeiller, "Fougères du Terrain houiller du Nord," *Bull. Soc. géol. France*, ser. 3, vol. xii, p. 201.
1914. *Dactylotheca dentata* Bureau, "Bassin de la Basse Loire," fasc. 2, "Flores foss.," *Études Gîtes Min. France*, p. 311, pl. lxxvii, fig. 1.
1886. *Pecopteris* (*Dactylotheca*) *dentata* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 196, pl. xxvi, figs. 1, 2; pl. xxvii, figs. 1–4; pl. xxviii, figs. 4, 5.
1890. *Pecopteris* (*Dactylotheca*) *dentata* Zeiller, "Flore foss. bassin houil. et perm. d'Autun et d'Épinac," fasc. 2, "Flore foss.," pt. 1, *Études Gîtes Min. France*, p. 66, pl. ix*a*, fig. 3.
1892. *Pecopteris* (*Dactylotheca*) *dentata* var. *obscura* Zeiller, "Flore foss. bassin houil. et perm. de Brive," *Études Gîtes Min. France*, p. 26, pl. ii, figs. 1–5.
1899. *Pecopteris* (*Dactylotheca*) *dentata* White, "Foss. Flora Lower Coal Meas. of Missouri," *Mon. U.S. Geol. Surv.*, vol. xxxvii, p. 75, pl. xxiv, figs. 1, 2; pl. xxv; pl. xxvi, figs. 2–4; pl. xxvii.
1836. *Aspidites Silesiacus* Göppert, "Syst. fil. foss.," p. 364, pl. xxvii; pl. xxxix, fig. 1.
1838. *Steffensia Silesiaca* Presl in Sternberg, "Versuch," vol. ii, fasc. vii, viii, p. 122.
1845. *Pecopteris Silesiaca* Unger, "Synop. plant. foss.," p. 97.
1869. *Pecopteris Silesiaca* Schimper, "Traité de paléont. végét.," vol. i, p. 517.

1877. *Pecopteris Silesiaca var.* Lebour, " Illus. of Fossil Plants," p. 53, pl. xxvi.
1836. *Pecopteris delicatula* Brongniart, " Hist. des végét. foss.," p. 349, pl. cxvi, fig. 6.
1838. *Pecopteris delicatula* Sternberg, " Versuch," vol. ii, fasc. vii, viii, p. 157.
1869. *Pecopteris delicatula* Schimper, " Traité de paléont. végét.," vol. i, p. 510.
1873. *Pecopteris delicatula* Breton, " Étude géol. du sud de la Concession de Dourges " (Lille), p. 412, pl. vii, fig. 2.
1848. *Cyatheites delicatulus* Bronn, " Index palæont.," p. 364.
1886. *Pecopteris* (*Dactylotheca*) *dentata*, var. *delicatula* Zeiller, " Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 199, pl. xxviii, fig. 5.
1890. *Dactylotheca plumosa* var. *delicatula* Kidston, *Trans. Yorks. Nat. Union*, pt. 14, p. 36.
1838. *Pecopteris Brongniartiana* Presl in Sternberg, " Versuch," vol. ii, fasc. vii, viii, p. 160.
1836. *Aspidites Glockeri* Göppert, " Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, Band xvii, p. 375, pl. xxix, figs. 1, 2.
1845. *Pecopteris Glockeriana* Unger, " Synop. plant. foss.," p. 98.
1854. *Pecopteris Glockeriana* Ettingshausen, " Steink. v. Radnitz," *Abhandl. k. k. geol. Reichsanst.*, Band ii, Abth. 3, No. 3, p. 44, pl. xvii, fig. 1.
1854. *Pecopteris angustifida* Ettingshausen, *Ibid.*, p. 45, pl. xvi, fig. 1.
1885. *Senftenbergia stipulosa* Stur, " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band viii, Heft 2, p. 80, pl. xlvi, figs. 4, 5 ; pl. xlvii, figs. 1, 2.
1888. Cf. *Pecopteris Bioti* Zeiller, " Études terr. houil. de Commentry, Flore foss.," *Bull. Soc. Ind. min.*, vol. ii, Livr. 2, p. 99, pl. ix, figs. 2–4.

Description.—Frond very large, probably tripinnate in upper part, and quadripinnate towards its base. Main rachis of frond straight, and attains a width of 1·5 cm. when compressed ; densely punctate with very small papilla-like emergences, which are often not shown through absence of the epidermis or imperfect preservation. Primary pinnæ large, lanceolate, and subtended by a stipule situated at the point of their departure from the main rachis. Stipules or aphlebia of a deltoid contour, with a flattened central axis from which spring alternate lateral segments which divide into flat, narrow, pinnate or bipinnate, sharp-pointed segments. Secondary pinnæ lanceolate, the larger reaching a length of 22 cm. or more. Tertiary pinnæ linear-lanceolate, with a length of at least 6 cm., and twenty-four or more pairs of pinnules.

Pinnules alternate, more or less oblique, and united to the rachis by the whole width of their base. They vary much in form, size, and pinnule-cutting, according to the position on the frond of the pinnæ bearing them ; they are entire, or with sinuous or lobed margins, or bear small, obtuse, tooth-like crenatures. The pinnules on the middle ultimate pinnæ are oval-triangular or broadly lanceolate, with rounded apices, and united by the whole width of their base to the rachis. The basal inferior pinnule is deltoid-rounded, generally smaller than the others, and occupies the angle formed by the insertion of the pinna on its parent rachis, and frequently has a distinct lobe ; the superior basal pinnule is oval or oval-oblong, obtuse, and is almost invariably the largest pinnule on the pinna. The uppermost pinnules become gradually more united to each other and form a more or less lobed, and finally an entire blunt apex to the pinna. As the pinnæ are traced upwards, they become lobed or crenate through the gradual increase in extent of the union of the pinnules to each other, and in some cases finally assume the form of pinnules with blunt-pointed apices. As the pinnæ are traced towards the base of the frond, the pinnules on the tertiary pinnæ become more and more distinctly lobed till they take the form of small quadripinnate pinnæ.

Nervation.—The median vein extends to the apex, and is usually slightly decurrent at the base though sometimes straight. In the larger pinnules the lower lateral veinlets generally divide once, while the upper ones are simple; in the smaller pinnules, and in those holding upper positions on the pinnæ, the veins are undivided. In the dentate or crenate pinnules each little lobe is usually provided with a single veinlet.

Sporangia exannulate, oval or oval-acute, varying in length from 0·50 mm. to 0·75 mm., with walls formed of slightly elongated coriaceous cells. They are placed upon and parallel with the lateral veinlets, at a short distance above their base. In the smaller and crenate pinnules the sporangia frequently occupy the whole space between the midrib and the margin, and the limb of the pinnule is usually slightly reduced, especially when the sporangia are copiously produced. The upper portion of the fertile pinnæ is sometimes sterile.

Remarks.—The fronds of *Dactylotheca plumosa* Artis sp. attained a very large size. A specimen from Radstock, of which a portion is seen natural size on Pl. XCII, shows, I believe, portions of two primary pinnæ, and is 39 cm. in length and 30 cm. in breadth, though incomplete at both apex and base. The largest secondary pinna, though also imperfect at the upper end, measures about 17 cm. Some of the lower secondary pinnæ on this example have a greater width and presumably must have been of greater size. One of the pinnæ on Göppert's figure of his *Aspidites Silesiacus,* which is the *Sphenopteris crenata* of Lindley and Hutton and only a form of *Dactylotheca plumosa,* though incomplete, is 45 cm. in length.

The figures given on our plates convey a much better idea of the various forms of pinnule-cutting that occur in this species than can be given by a verbal description. From simple undivided pinnules to others divided in distinct small lobes, there are intermediate forms which graduate into each other by imperceptible transitions. On some specimens the simple undivided pinnule is found in association with those bearing prominent lobes. To these polymorphic forms many specific names have been given, and reference will be made to them in the description of the specimens figured on the plates.

That these so-called species are only different portions of a single species and might well be fragments of an individual frond is now generally recognized, and will, I believe, be admitted by anyone who has the opportunity of examining a large series of specimens of *Dactylotheca plumosa* Artis sp.

These various forms cannot even consistently be described as varieties, since they merely represent different portions or conditions of development of the frond, but should it be thought desirable to distinguish any particular *form* it can be done by distinguishing them as *forma crenata, forma dentata,* etc.

On Pl. XCIII, fig. 2, is seen natural size the upper portion of an imperfect specimen 26 cm. in length. It shows the main rachis of the frond which, at a lower level than that seen in the figure, is 8 mm. in breadth. The outer surface of the part of the rachis seen in the figure is quite smooth and does not show any trace of small apiculæ, but at the base of the specimen they are distinctly seen. Their absence on part of the rachis is, therefore, due to imperfect preservation. That this example exhibits the main rachis of the frond is shown by the presence of the aphlebiæ, which seem usually to have been borne only at the point of insertion of primary pinnæ, though ZEILLER mentions an example in which they were borne at the base of the secondary pinnæ.* These aphlebiæ were originally named *Schizopteris adnascens* by LINDLEY and HUTTON in the belief that they were a distinct plant which had twisted itself round the rachis.

The pinnules are not very well preserved on this example, but sufficiently preserved for its easy identification with the *Sphenopteris crenata* L. and H.

Another example showing aphlebiæ is seen natural size at fig. 3, Pl. XCIII. These are larger than those just described, and the rachis bearing them is also wider, having a breadth of 1·4 cm. It therefore probably represents a portion of the main rachis from a lower level of the frond than that given at fig. 2 of the same plate. The coaly surface of the rachis is smooth, but the impression at the upper end shows its apiculation very distinctly.

The aphlebiæ are formed of a flat central axis from which are given off lateral segments of a similar flattened form that further divide and terminate in sharp points. That these aphlebiæ acted as protective organs for the young growing parts of the frond is seen at fig. 4 of the same plate. Here are seen the young circinately-rolled pinnæ embedded in a mass of aphlebiæ in close relationship to each other through the internodes of the rachis being still incompletely developed.

The typical form of the plant, at least that to which the name of *plumosa* was given by ARTIS, is seen natural size at fig. 1, Pl. XCIV. The pinnules are entire, or have only a slightly sinuous margin, and two are enlarged at fig. 1*a*. The median vein is very slightly decurrent, extends to the apex, and all the lateral veins are undivided. This specimen, like most of the examples figured here, is from the Barnsley Coal of Yorkshire, the horizon from which the type specimen was derived.

The typical form of *Dactylotheca plumosa* is also seen at the upper end of the specimen given at fig. 1, Pl. XCIII, though here the pinnules are smaller than those on the figure given by ARTIS. They are quite entire, elongate, and terminate in moderately sharp points. Two pinnules are enlarged four times from the upper part of the specimen at fig. 1*a*, which show these characters more clearly. The lower part of this example is not very well preserved, but it corresponds to the *Sphenopteris crenata* L. and H., in which the pinnules bear rounded teeth, as seen at figs. 1*b* and 1*c*, which are also enlarged four times.

A better example of the form of the plant to which LINDLEY and HUTTON gave the name of *Sphenopteris crenata* is seen at fig. 3, Pl. XCIV. The pinnules are broadly lanceolate, obtuse, and bear a number of small, rounded lobes. *Pecopteris serra*

* "Flore foss. bassin houil. de Valenciennes," p. 199.

L. and H. is a form scarcely differing from the type, the pinnules being described by LINDLEY and HUTTON as "attached by their whole base to the rachis, a little curved forwards, and very slightly wavy at the margin."

According to the figures and description given by GÖPPERT, his *Aspidites Silesiacus* does not appear to differ in any essential character from *Sphenopteris crenata* L. and H.

The specimen shown natural size on Pl. XCII has been already partially described. This I regard as part of a primary pinna. The specimen is beautifully preserved, and the small, closely-set punctations on the rachis are very distinctly seen. The slightly oblique, blunt-pointed, sub-triangular pinnules are characteristic of the specimen figured by BRONGNIART on his pl. cxxiii, fig. 1, under the name of *Pecopteris dentata* Brongniart.

A slightly varying form is given on Pl. CXII, fig. 2, natural size, and a small portion is enlarged two times at fig. 2*a*. The penultimate pinnæ are narrower in proportion to their length than is usual in this species, but the pinnules scarcely differ from those of the forma *dentata*. This is seen if one compares the enlargement given at Pl. CXII, fig. 2*a*, with the specimen seen on Pl. XCII. As is frequently the case in *Dactylotheca plumosa*, the lateral veinlets are all of the simple form given on Pl. CXII, fig. 2. Some pinnules are enlarged seven times at text-fig. 32 to show their form and nervation.

TEXT-FIG. 32.—*Dactylotheca plumosa* Artis sp. Pinnules enlarged seven times to show form and nervation. Kidston Collection, No. 2116.

I possess another fine example (No. 358) from the Radstock Group, on which the pinnules on the uppermost pinnæ of the specimen are identical with those on the figure given by ARTIS of his *Filicites plumosus*. The pinnules on the slightly lower pinnæ agree with those shown on the figure given by BRONGNIART on his pl. cxxiv, while on some other fragments of pinnæ, which appear to belong to a primary pinna from a lower position on the same frond, some of the pinnæ bear pinnules similar in form and nervation to that given by BRONGNIART on pl. cxxiii, figs. 4 and 4*a*. It is therefore impossible to draw a line separating *Pecopteris dentata* Brongniart from *Filicites plumosus* Artis.

A form with small pinnules of the "dentata" shape is seen at figs. 2, 2*a*, and 2*b*, Pl. XCIV.

In the form described as *Pecopteris delicatula* by BRONGNIART, the pinnules are small, entire, more narrow in proportion to their length, and usually have sharp points. It might in fact be described as a small-pinnuled *Filicites plumosus*, and is almost identical with the specimen already described and shown on Pl. XCIV, fig. 1. A specimen in my collection (No. 1134) from the Barnsley Coal, Monckton Main Colliery, near Barnsley, collected by Mr W. HEMINGWAY, is identical with BRONGNIART'S figure of *Pecopteris delicatula* in the size, form, and nervation of the pinnules. Specimen No. 3772 also shows the same plant. The form is not uncommon.

Another small-pinnuled form is given at figs. 1 and 1*a*, Pl. XCV. Here the pinnules (or small pinnæ with the pinnules run together) are crenate, narrow, and long in proportion to their width. This is a form of *Sphenopteris crenata* L. and H., or *Aspidites Silesiacus* Göppert, which corresponds to that of *Pecopteris delicatula* in its relation to *Filicites plumosus*.

The form named *Sphenopteris caudata* by Lindley and Hutton on their pl. xlviii is illustrated on Pl. XCVI, figs. 3, 3*a*. This is merely another example of the *Sphenopteris crenata* type, in which the oblique pinnules are united to each other for about half their length, and is comparable with the specimen seen at fig. 1, Pl. XCV, but larger in all its parts. On the second figure of the species given by Lindley and Hutton on their pl. cxxxviii the pinnæ are broader and the pinnules larger.

The fertile pinnules sometimes seem to undergo a slight reduction of the limb, especially in the larger-pinnuled form of the species. In other cases, the fertile pinnules are similar in form to those of *Sphenopteris crenata* L. and H., as on the example figured on Pl. XCV, fig. 2. Whether this form in the fertile condition is due to the reduction of the limb through the presence of the sporangia, or simply a fertile specimen of the "crenata" form of the species, is difficult to determine. Each little lobe bears two rows of sporangia which cover the entire under-surface of the pinnules. A sporangium is enlarged twenty-six times at fig. 2*a*.

At fig. 3 some sporangia are given from another specimen enlarged twenty-eight times. These are more oval and less pointed than that seen at fig. 2*a*, but vary slightly in size and form; they are exannulate, and the walls are formed of slightly elongated cells.

On fertile pinnules of larger size than those of the specimen seen at fig. 2, Pl. XCV, the sporangia are placed towards the margin and do not cover the whole of the under-surface of the pinnule.

All the specimens of *Dactylotheca plumosa* described above are from the Radstockian and Westphalian Series, but the species occurs also in Lanarkian Series, where, however, it is extremely rare. Two specimens from this horizon are given on Pl. CX, figs. 1 and 2. That shown at fig. 1 has the punctate rachis characteristic of the species and narrow, crenate pinnules of the "crenata" form of the plant. The example given at fig. 2, which is in the Collection of the Geological Survey, Edinburgh, has entire or very slightly sinuous elongated pinnules with simple and bifid lateral veins. It corresponds fairly well to the type of Artis (who, however, does not give any enlarged view of the pinnules or mention the nervation), but the pinnules are slightly longer in proportion to their width.

The specimen given on Pl. XCVI, fig. 2, natural size, is provisionally referred to *Dactylotheca plumosa*. The pinnules are united to each other by their bases, and on the lower ultimate pinna are usually very obtuse, as seen in the enlargements, figs. 2*a* and 2*b*. At the apex of the specimen, however, where the lower bipinnate pinnæ assume the form of pinnate pinnæ, the pinnules are pointed, are very similar to those of *Dactylotheca plumosa* forma *dentata*, and have a like nervation. I therefore think it may be only a form of *Dactylotheca plumosa*. It was collected by Mr W. HEMINGWAY, to whom I am indebted for the only example of this particular form that I have seen.

The variety described by STERZEL under the name of *Pecopteris dentata* var. *saxonica* (*loc. cit.*) is a very distinct plant. The pinnules are placed close together or slightly overlap, are oblique, oblong, decurrent, contracted slightly at apex, and terminate in a blunt point, and have on their anterior margin a deep basal sinus, which extends inwards about half-way to the decurrent median vein. It differs so greatly from any form of *Dactylotheca plumosa* that it seems to demand specific rank.

Dr STOPES (*loc. cit.*) united *Neuropteris serrulata* Dawson and *Pecopteris serrulata* Hartt in DAWSON,* with *Dactylotheca plumosa* Artis sp., to which plant the specimens she figures under the name of *Pecopteris plumosa* evidently belong, but DAWSON'S figures are very unsatisfactory and show little resemblance to that species.

With *Dactylotheca plumosa* I would unite the specimens referred to *Pecopteris Bioti* by ZEILLER.† They seem to possess much more the characters of *Dactylotheca plumosa* than those of *Pecopteris Bioti*, where the ultimate pinnæ are shorter and narrower. On the other hand, his fig. 4 shows the distinctive aphlebiæ of *Dactylotheca plumosa*. The fact that the rachises of his specimens were smooth, which he regarded as a specific distinction, was probably due to imperfect preservation. On the two specimens given here on Pl. XCIII, figs. 2, 3, the punctations are seen on only one small part of the rachis in each case, and their absence from the other and larger portions is evidently due, therefore, to imperfect preservation.

It has generally been supposed that these apiculations mark the points from which scales had fallen. They appear rather to be small outgrowths, homologous to the spine-like appendages which occur on the stems and rachises of many fern or fern-like plants, though of small size.

The fertile specimen figured by the Abbé CARPENTIER ‡ under the name of *Pecopteris* (*Dactylotheca*) *plumosa* should, I think, be referred to the genus *Senftenbergia*, since a number of the sporangia show distinct indications of their having an apical annulus similar in structure to that of *Senftenbergia* Corda.

Distribution.—Dactylotheca plumosa Artis sp. ranges throughout the whole of the Upper Carboniferous. At the base, in the Lanarkian Series, it is extremely rare, and, so far as I know, has been met with there on only two occasions. In the Westphalian it is fairly common. It has also been collected from all three groups

* *Neuropteris serrulata* Dawson, *Quart. Journ. Geol. Soc.*, vol. xviii, p. 320, pl. xv, fig. 35A, B, 1862; *Neuropteris serrulata* Dawson, "Foss. Plants Devon. and Upp. Silur. Canada" (*Geol. Survey, Canada*), p. 49, pl. xviii, fig. 213, 1871; *Pecopteris* (*Alethopteris*) *serrulata* Hartt in DAWSON, "Acadian Geology," 2nd ed., p. 553, fig. 192, K. 1868; *Pecopteris* (*Aspidites ?*) *serrulata* Hartt in DAWSON, "Foss. Plants Devon. and Upp. Silur. Canada" (*Geol. Survey, Canada*), p. 55, pl. xviii, figs. 207–209, 1871; *Pecopteris* (*Aspidites ?*) *serrulata* Hartt in DAWSON (*ibid.*), pt. ii, p. 117, 1882; *Pecopteris serrulata* Dawson, "Geol. Hist. of Plants," p. 73, fig. 23, K. 1888.

† "Flore foss. terr. houil. de Commentry," *Bull. Soc. Ind. min.*, sér. 3, vol. ii, livr. 2, "Flore Foss.," pt. 1, p. 104, pl. ix, figs. 2–4.

‡ "Quelques graines et fructifications du Westphalien du Nord," *Revue générale de Bot.*, vol. xxvii, p. 331, pl. ix, figs. 6, 7, 1915.

of the Staffordian Series, but is very rare in that Series. In the Radstock Series it occurs as a common and characteristic plant.

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon: ?. *Localities:* Radstock, Somerset; Braysdown Colliery, near Radstock, Somerset; Wellsway Pit, near Radstock, Somerset; Kilmersden, near Radstock; Upper Conygre Pit, Timsbury, 2½ miles N.N.W. of Radstock, Somerset; Lower Conygre Pit, Timsbury, Somerset; Camerton, 2 miles north of Radstock, Somerset.

STAFFORDIAN SERIES.

Forest of Dean Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: "Third Division," Yorkley Coal. *Locality:* Park Gutter Colliery, Whitecroft Station (E. A. N. Arber).

South Staffordshire Coalfield.

ETRURIA MARL GROUP.

Horizon: Old Hill Marls. Within the upper 300 feet of the Group. *Locality:* Granville Pit, at Old Hill Station (Rev. H. Kay).

Kent Coalfield.

? ETRURIA MARL GROUP.

Horizon: At depths of 1620 feet and 3095–97 feet. *Locality:* Boring, Tower Brickworks, Folkestone (Collection of Geological Survey, London).

Lancashire Coalfield.

BLACKBAND GROUP.

Horizon: From between 24 feet and 321 feet above Bradford Four-feet Coal. *Locality:* Bradford Colliery, Manchester (W. Hemingway).

WESTPHALIAN SERIES.

Ayrshire Coalfield.

Horizon: A few feet below Ell Coal. *Locality:* Gerrallan Pit Sinking, ½ mile S.S.W. of Old Cumnock (Collection of Geological Survey, Edinburgh).

Horizon: About position of Ell Coal. *Locality:* Burnockhill Pit, Ochiltree (J. Smith).

Burnley Coalfield.

Horizon: Fulledge Thin or Yard Mine. *Locality:* Shaft sinking, Bank Hall Colliery, Burnley (P. Whalley).

Forest of Wyre Coalfield.

Horizon: Brooch Coal. *Localities:* Highley Colliery, Highley, Shropshire. Kinlet Colliery, 1 mile south-west of Highley, Shropshire (T. H. Stonehouse).

Horizon: ?. *Localities:* Railway Cutting, 150 yards south-east of Northwood House, a half mile north of Bewdley, Worcestershire (Collection of Geological Survey, London); Seckley Cliff, west bank of Severn, 450 yards south-west of Eymore Farm, ¾ mile south of Upper Arley, Worcestershire (Collection of Geological Survey, London); Roadside at back of building, Cooper's Mill, 1½ miles west of Dowles Church, near Bewdley, Worcestershire (Collection of Geological Survey, London); Billingsley Colliery, 1 mile south-east of Billingsley Church, Shropshire (E. A. N. Arber).

Lancashire Coalfield.

Horizon: Forty yards above Arley Mine. *Locality:* Spath, near Rochdale (W. H. Sutcliffe).

Horizon: Brassey Mine. *Locality:* Linnyshaw Pit, Worsley.

Horizon: A short distance above Doe Mine. *Locality:* Dixon Fold, Stoneclough.

Horizon: "Forest Bed." *Locality:* Oldham Edge, Oldham (J. Nield).

Horizon: Little Coal. *Locality:* Outwood Colliery, Radcliffe (J. Gerrard).

Horizon: Ravenwood Coal. *Locality:* Ravenhead, St Helens (Liverpool Museum).

Horizon: Trencher Bone Coal. *Locality:* Worsley.

Horizon: Yard Coal. *Locality:* Tonge, near Bolton.

Leicestershire and South Derbyshire Coalfield.

Horizon: Above Main Coal. *Locality:* Donisthorp, 4 miles south-west of Ashby-de-la-Zouch, Leicestershire (A. R. Horwood).

North Derbyshire and Nottingham Coalfield.

Horizon: Between Deep Hard Coal and Silkstone Coal. *Locality:* Bondsmain Colliery, Temple Normanton, 3 miles S.S.E. of Chesterfield, Derbyshire (Collection of Geological Survey, London).

Horizon: Silkstone Coal. *Locality:* Bondsmain Colliery, Temple Normanton, Derbyshire (L. Moysey).

Horizon: ?. *Locality:* Clay Cross (Rev. J. M. Mello).

Horizon: 261 feet below Top Hard Coal. *Locality:* Summit Colliery Sinking, Kirby-in-Ashfield, Nottinghamshire (L. Moysey).

North Staffordshire Coalfield.

Horizon: Below New Mine Coal. *Locality:* Adderley Green, near Longton (J. Ward).

Horizon: Roof of Peacock Coal. *Locality:* Glebe Colliery, Fenton.

North Wales Coalfield.

Horizon: Roof of Crank Coal. *Locality:* Wrexham Colliery, about $\frac{3}{4}$ mile north of Wrexham, Denbighshire (Collection of Geological Survey, London).

Horizon: Two-yard Coal. *Locality:* Llay Hall Colliery, $2\frac{7}{8}$ miles N.N.W. of Wrexham, Denbighshire (Collection of Geological Survey, London).

Horizon: Hollin Coal. *Localities:* Main Coal Co., $3\frac{3}{8}$ miles N.W. of Hawarden Station, Flintshire (Collection of Geological Survey, London); Elm Colliery, nearly $2\frac{1}{4}$ miles N. of W. of Hawarden Station, Flintshire (Collection of Geological Survey, London).

Horizon: Between 1–33 yards above Yard Coal. *Locality:* Sinking at Cefn-y-Coed Colliery, near Pontybodkin, Flintshire (Collection of Geological Survey, London).

Horizon: Roof of Yard Coal. *Locality:* Phœnix Coal and Cannel Company's Pit, $3\frac{1}{8}$ miles S.S.E. of Mold Station, Flintshire (Collection of Geological Survey, London).

Northumberland and Durham Coalfield.

Horizon: Bensham Seam. *Locality:* Jarrow Colliery, Jarrow, County of Durham.

Horizon: Crow Coal. *Locality:* Phœnix Brickworks, Crawcrook, Ryton (W. Eltringham).

Horizon: High Main Seam. *Locality:* Jarrow, County of Durham (Hancock Museum, Newcastle-upon-Tyne).

South Staffordshire Coalfield.

Horizon: Above Brooch Coal. *Locality:* Greets Green, near West Bromwich, Oldbury.

Horizon: Blue Measures, 6 feet above Brooch Coal. *Locality:* Hamstead Colliery, Great Barr, $2\frac{1}{2}$ miles S.E. of Walsall (H. Insley).

Horizon: Roof of Bottom Coal. *Locality:* Bradley Colliery, Bilston.

Horizon: Blue Measures, 6 feet above Fire Clay Coal. *Locality:* Doulton's Marl Pit, Netherton (H. W. Hughes).

Horizon: Between Fire Clay Coal and Bottom Coal. *Locality:* Doulton's Marl Pit, Netherton (H. W. Hughes).

Horizon: Roof of Fire Clay Coal. *Locality:* Russell's Hall, Dudley.

Horizon: Roof of New Mine Coal. *Locality:* Coseley, Clattershall Colliery, Brettell Lane, $1\frac{1}{2}$ miles N.E. of Stourbridge.

Horizon: Ten-foot Ironstone Measures. *Locality:* Clayscroft openwork, Coseley, near Dudley.

Horizon: Roof of Thick Coal. *Locality:* Bradley Colliery, Bilston.

Horizon: Five yards above White Ironstone. *Locality:* No. 19 Pit, Salkwells, Cradley, 3 miles E.N.E. of Stourbridge.

SOUTH WALES COALFIELD.

Horizon: Coal Seam in Cliff. *Locality:* Two yards west of "old level," and nearly 600 yards east of Amroth Castle, Carmarthenshire (Collection of Geological Survey, London).

TITTERSTONE CLEE HILL COALFIELD.

Horizon: Within 42 yards above Gutter Coal. *Locality:* Pit, about ¼ mile E.N.E. of Gobbits, Cleeton (E. E. L. DIXON).

Horizon: Near Gutter Coal. *Locality:* Colliery, 350 yards north-east of St Paul's Church, Knowbury (E. E. L. DIXON).

Horizon: About 77 feet above Gutter Coal. *Locality:* Chimney Pit Boring, Angelbank, Titterstone Clee (R. L. ROBERTS).

Horizon: 138 feet below Great Coal. *Locality:* Chimney Pit Boring, Angelbank, Titterstone Clee (R. L. ROBERTS).

Horizon: About 230 feet below Four-feet Coal. *Locality:* Chimney Pit Boring, Angelbank, Titterstone Clee (R. L. ROBERTS).

Horizon: A few feet below Smith Coal. *Locality:* Chimney Pit Boring, Angelbank, Titterstone Clee (R. L. ROBERTS).

WARWICKSHIRE COALFIELD.

Horizon: Ryder Coal. *Locality:* Baddesley Colliery, 2 miles W.S.W. of Atherstone (R. D. VERNON).

YORKSHIRE COALFIELD.

Horizon: Above Beeston Bed. *Localities:* Clark Lane, Leeds (J. W. BOND); Marsh Lane Tunnel, Leeds (J. W. BOND).

Horizon: Below Black Bed Coal. *Locality:* Dolly Lane Brickworks, Leeds (J. W. BOND).

Horizon: Haig Moor Coal. *Locality:* Crigglestone Colliery, Crigglestone (W. HEMINGWAY).

Horizon: Rock below Haig Moor Coal. *Locality:* Brightside, near Sheffield (W. HEMINGWAY).

Horizon: Old Hards Coal. *Locality:* Hartley Bank Colliery, Horbury (W. HEMINGWAY).

Horizon: Near outcrop of Stanley Main Coal. *Locality:* Shale Quarry, Roundwood, Ossett (S. NETTETON).

Horizon: Barnsley Coal. *Localities:* Monckton Main Colliery, near Barnsley (W. HEMINGWAY); Woolley Colliery, Darton, near Barnsley (W. HEMINGWAY); South Kirby Colliery, near Pontefract (W. HEMINGWAY); Hickleton Main Colliery, Thurnscoe, near Rotherham (W. Gelder); Fence Colliery, near Rotherham (W. Gelder); Cooper's Colliery, Worsborough Dale, near Barnsley (W. Gelder); East Gawber Colliery, near Barnsley (W. Hemingway); Elsecar, near Barnsley (Artis, type of Species).

Horizon: Warren House Coal. *Locality:* Glasshoughton Pit, Castleford (Dr Welburn).

Horizon: Winter Coal. *Locality:* Wheatley Wood Colliery, near Barnsley (W. Hemingway).

LANARKIAN SERIES.

Fife Coalfield.

Horizon: Lower Coxtool Coal. *Locality:* East Newton, Wemyss (J. Kirkby).

Lanarkshire Coalfield.

Horizon: From bed situated in the Lanarkian Series, but exact position not determined. *Locality:* Hallhill Burn (tributary of River Nethan), fully 1 mile south-west of bridge across River Clyde at Crossford (Collection of Geological Survey, Edinburgh).

Dactylotheca Sturi Sterzel pro var.

Plate XCIV, figs. 4, 4*a*, 5, 6.

1875. *Senftenbergia aspera* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 299 (193), pl. xxviii (xi), figs. 10, 10*a*.
1899. *Senftenbergia aspera* Hofmann and Ryba, "Leitpfl. d. palaeoz. Steink.," p. 70, pl. vii, figs. 12, 12*a*.
1901. *Pecopteris* (*Dactylotheca*) *aspera* forma *Sturii* Sterzel, "Paläont. Charakter d. Steinkohl. u. d. Rothl. von Zwickau," *Erläuterungen z. geol. Specialkarte d. König. Sachsen*, Section Zwickau, p. iii.

Compare also :—

1886. *Pecopteris* (*Dactylotheca*) *aspera* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 202, pl. xxix, figs. 1–3.
1910. *Pecopteris aspera* and *Dactylotheca aspera* Gothan in Potonié, "Abbild. u. Beschreib. foss. Pflanzen," Lief. 7, No. 121, figs. 1–3.
1913. *Pecopteris* (*Dactylotheca*) *aspera* Gothan, "Oberschlesische Steinkohlenflora," Teil 1, *Abhandl. k. preuss. geol. Landesanst.*, N.F., Band lxxv, p. 149, pl. xxxi; pl. xxxii, fig. 1.

Description.—Frond at least quadripinnate. Stem (?) 1·5 cm. in breadth, straight, outer surface bearing numerous, closely-placed, small apiculæ. Primary pinnæ alternate, lanceolate; rachis 3·5 mm. or more in breadth, apiculate, but apiculæ fewer and more distant than on the (?) stem, and bearing many pairs of secondary pinnæ. Secondary pinnæ: basal pinnæ narrow-deltoid, margins touching or slightly overlapping; upper pinnæ free and slightly distant, more or less lanceolate, regularly contracting from the base and ending in a blunt apex. Tertiary pinnæ narrow-lanceolate with obtuse apex, free till near the extreme apex of the secondary pinnæ, where they become confluent and the pinna terminates in a more or less entire or crenate long blunt-pointed lobe. Pinnules on lower-placed tertiary pinnæ free, oblong, more or less contracted and rounded at base, gradually narrowing upwards, with one or more pairs of not very prominent rounded lateral lobes; on upper-placed pinnæ the pinnules become more and more united to each other until they merely form a crenulate margin to the rachis, and ultimately form an oblong terminal lobe.

The median vein gives off lateral veinlets, the lower of which are usually bifid, the upper undivided.

Sporangia oval, about 0·5 mm. in length, exannulate, with walls formed of small cells.

Remarks.—Two distinct species seem to have been described under the name of *Pecopteris aspera* Brongniart. Sterzel * expressed the opinion that the plants figured by Brongniart † and Zeiller ‡ under the name of *Pecopteris aspera* were distinct from that described by Geinitz § and by Stur.|| That described by Geinitz he distinguished as forma *Hainichensis*, and the latter as forma *Sturii* (" Dagagen lassen sich *Cyatheites aspera* H. B. Geinitz (Hainichen-Ebersdorf, Taf. iii, fig. 3) und *Senftenbergia aspera* Stur (Culmflora ii, Taf. xi, fig. 10) kaum mit der Brongniart'schen Form identificiren. Beide sind auch unter sich verschieden und als *forma Hainichensis* und *Sturii* abzutrennen. Die vorliegende Art ist demnach keine Culmpflanze ").

In his later work,¶ after figuring and describing a number of specimens which he refers to *Pecopteris* (*Dactylotheca*) *aspera* Brongniart, he says (p. 672): " Nachdem ich an vielen Exemplaren die verschiedenen Erhaltungszustände und die Variabilität von *Pecopteris aspera* gesehen habe, halte ich eine Abtrennung von forma *Hainichensis* und forma *Sturi* (vergl. Synonymik) für unnötig." He therefore departs from the opinion he expressed in 1901.

Without a careful examination of the various figured specimens it is difficult, if not impossible, to decide the question satisfactorily, but so far as I can judge, there are two species included under the name of *Pecopteris aspera*. Moreover, I have no doubt that the plant figured by Sterzel is specifically distinct from that given by Stur under the name of *Senftenbergia aspera*.

The plant described here has been found at only one locality in Britain, so far as I am aware, but there it seemed to be fairly plentiful, although usually in a fragmentary condition. Three specimens are figured natural size on Pl. XCIV, at figs. 4–6, and a small part of fig. 4 is enlarged two times at fig. 4*a*. Portion of what I regard as a stem is given at fig. 6, natural size. This shows the small very close punctations covering the whole of its surface. At fig. 4 a fragment of a primary pinna from an upper position on the frond is seen. Here the pinnules are all more or less united to each other and form crenate margins to the ultimate pinnæ, two

* *Loc. cit.*, p. 111.

† " Hist. des végét. foss.," p. 339, pl. cxx, figs. 1–4.

‡ *Loc. cit.*

§ *Cyatheites aspera*, " Darst. d. Flora d. Hainich-Ebersdorfer," p. 43, pl. iii, fig. 3.

|| *Loc. cit.*

¶ " Karbon- und Rotliegendenflora im Grossherzogtum Baden," *Mitt. Badischen geol. Landesanst.*, Band v, Heft 2, p. 672, 1907.

of which are enlarged two times at fig. 4*a*. Fragments of two other secondary pinnæ are shown natural size at fig. 5. This specimen has held a lower position on the frond than that just described. The pinnules are free, slightly contracted at the base, with one or two pairs of little rounded lobes on their margins.

These specimens seem to correspond exactly with those described and figured by STUR,* which STERZEL originally proposed to distinguish as *var. Sturii.*

It is difficult to determine whether STUR's and BRONGNIART's plants are specifically identical, but I do not think they are. I have therefore adopted as the name for my specimens *Dactylotheca Sturi* Sterzel pro var., since this indicates clearly the exact kind of plant found in Britain. In the synonymy given here, the first three references are applicable to our plant, but I have added some others, under the heading "Compare also," which may belong to the same species, but I leave this an open question.

The plant has been placed in *Senftenbergia* by STUR, who describes the sporangia as oval, sessile, superficial, with a rudimentary apical annulus; and he further arrives at the conclusion, that the annulus of *Senftenbergia* was not clearly marked off from the other cells of the sporangial wall, and that the apical cells become gradually reduced in size as traced to the base of the sporangium (*loc. cit.*, p. 189). That such was the structure of the sporangia of his *Senftenbergia aspera* need not be doubted, though he does not figure them. He figures two sporangia, however, one named *Senftenbergia elegans*, which shows only the annulus of the sporangia (see *post*, p. 475), and the other *Senftenbergia Biotii*, which agrees with the above description, but does not show any annulus. On the other hand, the sporangia of *Senftenbergia elegans*, which he believed to be similar to those he figured, have a most prominent and conspicuous apical annulus, absolutely distinct from the two figures which he referred to that genus.†

A few sporangia are shown on two of our specimens (Nos. 5418 and 5423). These are oval or oval-oblong, and have a length of about 0·50 mm. The small cells forming the walls of the sporangia are distinctly indicated and show that the sporangia are exannulate, agreeing in this respect with those examined by ZEILLER and described in his "Flore foss. bassin houil. de Valenciennes" as ovoid, sharp-pointed at the summit, independent the one from the other, and situated on the veins of the last order with their points turned to the external margin of the lobes. In our specimens, however, the sporangia are obtuse at apex, but in *Dactylotheca plumosa* the sporangia sometimes have obtuse and at other times more sharp-pointed apices.

The British examples must, therefore, be referred to the genus *Dactylotheca*. GOTHAN ‡ unites *Senftenbergia spinulosa* Stur § with *Dactylotheca aspera*, but the rachis of that species bears long spine-like outgrowths, not the small apiculæ of all

* "Culm Flora," pl. xxviii, fig. 10.

† See P. BERTRAND, "Échantillon fructifié de *Pecopteris pennæformis*," *Ann. Soc. géol. du Nord*, vol. xli, p. 222, pl. vi, figs. 1–6, 1912.

‡ "Oberschlesische Steinkohlenflora," p. 149.

§ "Carbon-Flora d. Schatzlarer Schichten," p. 101, pl. xlviii, fig. 6.

the plants that have been included in *Pecopteris aspera*. *Sphenopteris spinulosa* Stur sp. is certainly specifically distinct from the plant here named *Dactylotheca Sturi*. (See *ante*, p. 72.)

Distribution.—Known from only one locality, where, however, it is frequent.*

CARBONIFEROUS LIMESTONE SERIES.

UPPER LIMESTONE GROUP.

Horizon: Bed between No. 4 and No. 5 Limestone. *Locality:* Shore near high-water mark where road takes a sharp bend at Cuthill, between Musselburgh and Prestonpans, Haddingtonshire.

Dactylotheca parallela Kidston n.sp.

Plate CXIII, figs. 5–8.

Description.—Frond tripinnate. Primary pinnæ; rachis very broad, 3–4 mm. in width, with fine longitudinal striations. Secondary pinnæ alternate, rachis straight, with fine longitudinal striations, springing from primary rachis at almost right angles, lanceolate, 4 cm. or more in length and bearing about twenty pairs of pinnules. Pinnules alternate, oblique to rachis, decurrent, slightly contracted at base on anterior margin, oblong, attached by their whole width to the rachis. Sides almost parallel till near the apex, where they terminate in a rounded, blunt point. Median vein thick; on each side is a row of sporangia placed at right angles to the midrib and occupying the whole space between it and the margin of the pinnule. Sporangia 0·75 mm. in length and 0·50 mm. in breadth, exannulate, oval, rounded at both ends, free, usually touching each other laterally, wall formed of small elongated cells.

Sterile condition of plant unknown.

Remarks.—The only example of this species that I have seen is figured natural size on Pl. CXIII, fig. 5, of which the counterpart is also preserved. It occurs on a very dark-coloured shale only slightly lighter in colour than the carbonaceous matter of the specimen. I think the specimen shows part of a primary pinna, and have drawn up the description in accordance with this view. The main rachis is very broad in comparison with the rachises of the secondary pinnæ.

Part of three secondary pinnæ are seen at fig. 6 enlarged two times. The pinnules are oblong, with straight sides and rounded apices, the longer of which have a length of 10–11 mm. and a breadth of about 2 mm. They are placed close together, the decurrent base of the pinnule becoming merged in the little sinus formed by the

* The record for *Pecopteris pennæformis* Brongniart from the Radstock Coalfield must be cancelled, as the specimen so named was subsequently found to have been inaccurately determined (Kidston, "Fossil Flora of Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 367).

contraction at the base of the anterior margin of the pinnule placed immediately below. The pinnules seem to be free, but if connected, it is only by the extreme end of the decurrence on their posterior margins.

The sporangia lie at right angles to the midrib of the pinnule and completely obscure the lateral veinlets on which they would appear to be placed, as seen at fig. 7, which is enlarged about ten times. That they were also free is distinctly seen in the sporangia enlarged twenty-five times at fig. 8. The wall of the sporangia seems to have been coriaceous and is composed of small elongated cells.

It is with some doubt that I place this species in the genus *Dactylotheca* Zeiller, but it agrees in the position of the sporangia on the veins, in their general form and structure (though their arrangement on the pinnules is more regular in forming a single row on each side of the midrib) and in their occupying the whole of the limb lying between the median vein and the margin. The essential characters of the species, however, seem to agree well with those of *Dactylotheca*, in which genus, for the present at all events, it may find a convenient place.

The fertile pinnules of *Dactylotheca parallela* have a very strong superficial resemblance to the figures of certain Carboniferous plants which have been compared with, or supposed to be related to, the existing Marattiaceous genus *Danæa*. Among these may be mentioned *Danæites asplenioides* Göppert,* *D. saræpontanus* Stur,† *Pecopteris Danæotheca* Grand'Eury,‡ and *Parapecopteris neuropteroides* Grand'Eury,§ but in all of these the sporangia are said to be united and to form oblong synangia. Had the sporangia of *Dactylotheca parallela* been less perfectly preserved, the plant might easily have been mistaken for a form of *Danæites*; and in some of the species mentioned above may not the recognition of supposed synangia be uncertain on account of imperfect preservation? The figures that accompany the description of these supposed Marattiaceous plants are not very convincing.

In regard to the genus *Danæites*, more than one writer describes the sporangia as being provided with an apical pore, as in the recent genus *Danæa*, and this is repeated in more than one text-book, but, concerning the analogy between the fructification of *Danæa* and *Danæites*, Stur distinctly states || that complete agreement seems to exist, and that only observation is wanted as to the mode and manner of the opening of the sporangia in *Danæites*. Since Stur wrote the above, no investigator, so far as I am aware, has ascertained the mode of dehiscence of the sporangia of any of these supposed Carboniferous allies of *Danæa*. Therefore, the opinion that there were existing in Carboniferous times ferns of close affinity with the recent genus *Danæa* is not supported by well-substantiated observations.

Distribution.—*Dactylotheca parallela* is known from only one specimen, which was derived from the Lanarkian Series.

* "Syst. fil. foss.," p. 380, pl. xix, figs. 4–5, 1836.

† "Carbon-Flora d. Schatzlarer Schichten," p. 223, pl. lxi, fig. 2, 1885.

‡ "Flore Carb. du Dépt. de la Loire," p. 78, pl. vii, fig. 7, 1877.

§ "Geol. et paléont. du bassin houil. du Gard," p. 288, pl. v, figs. 2–4; pl. vi, figs. 25–26, 1890.

|| "Morph. u. Syst. d. Culm- u. Carbonfarne," *Sitzb. k. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, 1883.

LANARKIAN SERIES.

Horizon: Kiltongue Coal. *Locality:* Lochwood Colliery, Easterhouse, Lanarkshire (Kidston Collection, No. 2672).

Genus **Dicksonites** Sterzel.*

1881. *Dicksoniites* Sterzel, *Bericht d. Naturwiss. Gesellsch. zu Chemnitz,* vii, p. 226.
1883. *Dicksoniites* Sterzel, *Bot. Centralblatt.,* Band xiii, No. 8/9, p. 10.
1888. *Dicksonites* Zeiller, " Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France,* p. 62.
1917. *Dicksonites* Seward, " Fossil Plants," vol. iii, p. 167.

Description.—Pteridospermous plant. Synangia and seeds borne on different fronds. Fertile pinnules undergo little or no reduction of the limb. Synangia marginal, formed of lanceolate or linear microsporangia from 1 mm. to 1·50 mm. in length, and arranged in a little star-like group around a common point of attachment. Seeds with an oval, slightly-pointed nucule, surrounded by a narrow wing, and attached to a little cup-like receptacle situated at the apex of a veinlet close to the margin of the pinnule on the lower surface. The upper surface of the pinnule shows a small mammillate elevation corresponding to the depression on the lower surface of the pinnule, from which the seed is suspended.

Ramification of frond formed by a division of the petiole, and further divisions of the branches through a series of false dichotomies. Sterile foliage of the *Pecopteris* type.

Remarks.—The only species at present referred to the genus *Dicksonites* is *Filicites Pluckeneti* Schlotheim, which was included by Brongniart in his genus *Pecopteris.*

Dicksonites Pluckeneti is one of the few Pteridosperms of which the seed, microsporangia, and ramification of the frond are known.

The frequent presence of an abortive bud in the angle of divergence of the fork of the petiole, and the further divisions of the branches, has caused *Dicksonites* to be compared in the structure of its frond with that seen in the existing genus *Gleichenia,* and they appear to be formed on the same plan, but beyond this the two genera have little in common, *Dicksonites* being a seed plant and *Gleichenia* a fern. Comparisons between existing plants and those of Palæozoic age, based on vegetative organs, are valueless for the purpose of determining congeneric relationships.

Distribution.—The genus *Dicksonites* Sterzel is restricted to the higher zones of Upper Carboniferous rocks.

Dicksonites Pluckeneti Schlotheim sp.

Plate CIX, figs. 1–4; text-figs. 33–36.

1804. Schlotheim, " Flora der Vorwelt," p. 52, pl. x, fig. 19.
1820. *Filicites Pluckenetii* Schlotheim, " Petrefactenkunde," p. 410.

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* The preferable spelling *Dicksonites* for *Dicksoniites,* suggested by Zeiller, is adopted here. (See Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 62.)

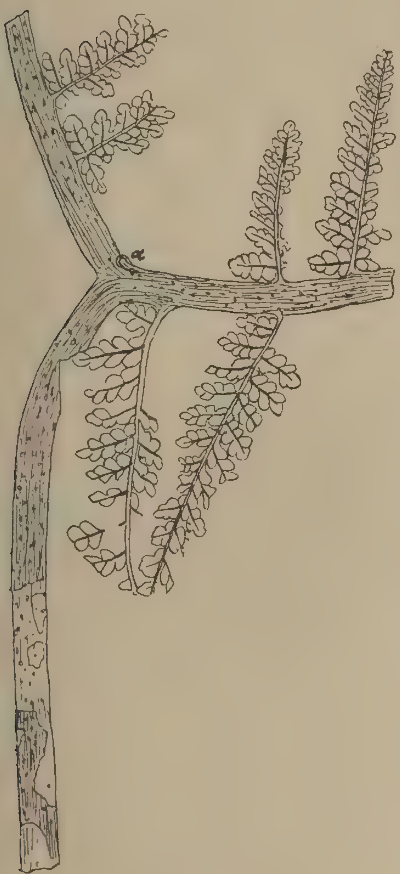
1832. *Filicites Pluckeneti* Schlotheim, " Merkwürdige Versteinerungen," p. 7, pl. x, fig. 19.
1828. *Pecopteris Pluckenetii* Brongniart, " Prodrome," p. 58.
1833. *Pecopteris Pluckenetii* Brongniart, " Hist. des végét. foss.," vol. i, p. 335, pl. cvii, figs. 1–3.
1826. *Pecopteris Pluckenetii* Sternberg, " Essai flore monde prim.," vol. i, fasc. iv, p. xix ; vol. ii, p. 150, 1838.
1845. *Pecopteris Pluckenetii* Unger, " Synop. plant. foss.," p. 96.
1847. *Pecopteris Pluckenetii* Germar, " Verstein. v. Wettin u. Löbejün.," p. 41, pl. xvi, figs. 1–4.
1869. *Pecopteris Pluckeneti* Schimper, " Traité de paléont. végét.," vol. i, p. 511 ; vol. iii, p. 495.
1872. *Pecopteris Pluckenetii* Heer, " Le monde prim de la Suisse," p. 16, fig. 14B.
1876. *Pecopteris Pluckenetii* Heer, " Flore foss. Helv.," p. 34, pl. x, fig. 6 ; pl. xiv, figs. 1–5 ; pl. xv, fig. 4.
1877. *Pecopteris Pluckeneti* Grand'Eury, " Flore Carbon. du Départ. de la Loire," *Mém. Acad. Sci., Paris*, xxiv, no. 1, p. 61.
1880. *Pecopteris Pluckeneti* Fontaine and White, " Perm. or Up. Carb. Flora," p. 67, pl. xxi, figs. 4, 5.
1880. *Pecopteris Pluckeneti* Zeiller, " Végét. foss. du terr. houil.," p. 90, pl. clxviii, figs. 1, 2.
1882. *Pecopteris Pluckeneti* Weiss, " Aus d. Flora d. Steinkohlenformation," p. 17, pl. xvii, fig. 100 ; Zweiter Abdr. (*K. preuss. geol. Landesanst.*).
1883. *Pecopteris Pluckeneti* Renault, " Cours de botan. foss.," vol. iii, p. 214, pl. xxi, figs. 6–9.
1883. *Pecopteris Pluckeneti* Zeiller, *Ann. Sci. Nat.*, 6e sér. Bot., vol. xvi, p. 201.
1893. *Pecopteris Pluckeneti* Potonié, " Flora d. Rothl. v. Thüringen," p. 81, pl. xii, figs. 1, 2, 5, 6 (3, 4 ?) (? pl. v, fig. 10).
1899. *Pecopteris Pluckeneti* Hofmann and Ryba, " Leitpflanzen," p. 53, pl. vii, figs. 6, 6*a*, 6*b*, 6*c*.
1900. *Pecopteris Pluckeneti* Zeiller, " Éléments de paléobot.," p. 89, fig. 63.
1902. *Pecopteris Pluckeneti* Zeiller, " Nouvelles observations sur la Flore fossile du Bassin de Kousnetzk (Sibérie)," *Comptes rendus Acad. Sci. Paris*, vol. cxxxiv, p. 889.
1905. *Pecopteris Pluckeneti* Grand'Eury, " Sur les graines trouvées attachées au *Pecopteris Pluckeneti* Schloth.," *Ibid.*, vol. cxl, p. 920. (3 pls.)
1905. *Pecopteris Pluckeneti* Zeiller, " Les Pteridosperms," *Revue générale des Sciences*, p. 725, fig. 7.
1907. Cf. *Pecopteris typ. Pluckeneti* Sterzel, " Karbon-u Rothl. im Grossherzog. Baden," *Mitt. Badischen geol. Landesanst.*, Band v, Heft 2, p. 499, pl. xxix, figs. 2, 3.
1917. *Pecopteris Pluckeneti* Seward, " Fossil Plants," vol. iii, p. 166, fig. 442.
1923. *Pecopteris Pluckeneti* Scott, " Studies in Fossil Botany," Third Edition, pt. 2, p. 222, fig. 85.
1836. *Aspidites Pluckenetii* Göppert, " Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 358.
1854. *Alethopteris Pluckeneti* Geinitz, " Flora d. Hainich-Ebersdorfer," p. 45.
1855. *Alethopteris Pluckeneti* Geinitz, " Verstein. d. Steinkohlenf. in Sachsen.," p. 30, pl. xxxiii, figs. 4, 5.
1869. *Cyatheites Pluckeneti* Weiss, " Foss. Flora d. jüngst. Stk. u. Rothl.," *Palaeontographica*, Band xvii, p. 67. pl. xii, fig. 4.
1877. *Diplothmema Pluckenetii* Stur, " Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 230.
1879. Cf. *Pseudopecopteris Pluckeneti* Lesquereux, " Coal Flora," vol. i, p. 199, pl. xxxiv, fig. 4 ; pl. xxxv, fig. 7.
1881. *Dicksoniites Pluckeneti* Sterzel, *Bericht d. Natur. Gesellsch. zu Chemnitz*, vii, pp. 223 and 226.
1883. *Dicksoniites Pluckeneti* Sterzel, " Ueber *Dicksoniites Pluckenetii* Schloth. sp.," *Botan. Centralblatt*, Band xiii, No. 8/9, p. 1, pl. vi, figs. 1–6.
1886. *Dicksoniites Pluckeneti* Sterzel, " Neuer Beitrag zur Kenntniss von *Dicksonites Pluckeneti* BRONGNIART sp.," *Zeitschr. deutsch. geol. Gesellsch.*, p. 773, pl. xxi.
1888. *Dicksonites Pluckeneti* Zeiller, " Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 62, fig. 40.
1899. *Pecopteris* (*Dicksonites*) *Pluckeneti* Zeiller, " Flore foss. bassin houil. d'Héraclée," *Mém. Soc. géol. France*, xxi, p. 37, pl. iii, fig. 11.
1899. *Dicksoniites Pluckeneti* Potonié, " Lehrb. d. Pflanzenpal.," p. 104, fig. 91.

1921. *Pecopteris* (*Dicksoniites*) *Pluckeneti* Gothan in POTONIE'S "Lehrb. d. Paläobot.," (Zweite Auflage), p. 93, fig. 84.
1826. *Pecopteris bifurcata* Sternberg, "Essai flore monde prim.," vol. i, fasc. iv, p. xix, pl. lix, fig. 2; vol. ii, fasc. vii–viii, p. 151, 1838.
1836. *Aspidites bifurcatus* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 359.
1845. *Sphenopteris* (*Aspidites*) *bifurcata* Unger, "Synop. plant. foss.," p. 68.
1850. *Sphenopteris bifurcata* Unger, "Genera et Species Plant. Foss.," p. 125.
1843. *Pecopteris Zwickaviensis* Gutbier, "Gaea von Sachsen," p. 83.
1885. *Diplothmema* (*Sphen.*) *Zwickauiensis* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. i, p. 296.
1845. *Pecopteris anthriscifolia* Göppert in TCHIHATCHEFF, "Descrip. des végét. foss. voyage scient. dans l'Altai Oriental, etc.," p. 387, pl. xxviii, fig. 9.
1845. *Sphenopteris imbricata* Göppert in TCHIHATCHEFF, *Ibid.*, p. 387, pl. xxix, figs. 10–13.
1853. *Pecopteris leptophylla* Bunbury in RIBEIRO, "On the Carbon. and Silur. Formations of Bussaco in Portugal," *Quart. Journ. Geol. Soc.*, vol. ix, p. 144, pl. vii, fig. 11.
1865. *Pecopteris leptophylla* Gomes, "Flora foss. do terr. carbon. das Visinhanças do Porto, Serra do Bussaco, etc.," *Commissão geol. de Portugal*, p. 22, pl. iii, figs. 2–3.
1885. *Diplothmema Beyrichi* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 389, pl. xxv*b*, figs. 3–5.
1877. Cf. *Carpolithes granulatus* Grand'Eury, "Flore Carbon du Départ. de la Loire," *Mém. Acad. Sci., Paris*, xxiv, no. 1, p. 306, pl. xxxiii, fig. 7.
1876. Cf. *Sphenopteris nummularia* Heer (*pars*), "Flora foss. Helvetiæ," p. 14, pl. xiv, fig. 6.

Description.—Pteridosperm. Petiole long, naked, longitudinally striated, bearing numerous small transversely-elongated elevations, and dividing into two arms at an open angle of sometimes about 150°. At the point of the fork and in a line with the petiole is generally a small bud-like structure which usually does not become further developed, though in rare cases it develops and continues the axis in the line of the petiole. This axis, as well as the two arms arising at the top of the petiole, again divides. Ultimate pinnæ alternate or sub-opposite, free, or touching laterally, lanceolate, broadest about the middle, whence the pinnules slightly decrease in size towards the base, and more quickly become smaller as traced towards the apex of the pinna, which narrows to a point. Pinnules upright or slightly oblique to rachis, varying considerably in the amount of their segmentation according to the position held by the pinna on the frond on which they occur. Those on the lower-placed pinnæ are free, oblong, slightly contracted at base, attached by a thick footstalk, and have an obtuse terminal lobe. They bear two to three pairs of opposite, round, convex segments, which are separated by an acute sinus that extends inwards about half-way to the midrib. Pinnules on higher-placed pinnæ oval, slightly contracted at base, decurrent and united to each other by a narrow band, feebly lobed or with sinuous margins. Those on uppermost pinnæ united for about half their length with an obtuse, rounded, free upper portion. A thick, slightly flexuous, decurrent median vein gives off lateral veinlets which dichotomize two or three times in their course to the margin. Fertile pinnules undergo little or no reduction of the limb.

Microsporangia and seeds not borne on the same frond. Microsporangia small, lanceolate, 1 to 1·50 mm. in length, and arranged in small stellate groups around a common point of attachment, and hold a similar marginal position on the pinnule to that occupied by the seeds. Seeds small, oval, 2·5 to 3·5 mm. in length, with a narrow surrounding wing, attached to a little cup-like receptacle at the end of the veins. A corresponding mamilla-like elevation is present on the upper surface of the pinnule.

Remarks.—STERZEL, who has given special attention to the ramification of the frond of *Dicksonites Pluckeneti,* describes it as formed by false dichotomies. The apex of the principal axis remains as an undeveloped bud-like structure in the bifurcation angle.



TEXT-FIG. 33.

TEXT-FIG. 34.

TEXT-FIGS. 33 and 34.—*Dicksonites Pluckeneti* Schlotheim sp. Ramification of frond. Figs. 33 and 34 (A) show undeveloped bud in line of the petiole. In Text-fig. 34 (B) the bud has developed and carries on the axis, which in turn dichotomizes. (From STERZEL.)

At text-figs. 33 and 34 are given three sketches of STERZEL's figures, illustrating these features.* Text-fig. 33 shows the naked petiole divided by a false dichotomy into two arms, and at *a* the undeveloped " bud " of the principal axis. At text-fig. 34 the bud is also seen at *a*. At text-fig. 34 (B) the bud of the principal axis has developed as a branch and carries the axis on for a short distance, when it also divides. The lateral arms *b, b* also dichotomize. Whether the branch *c* possessed a " bud " in the

* STERZEL, *Botan. Centralblatt,* Band xiii, 1883, pl. v, figs. 1, 2, and 3.

bifurcation angle could not be determined, on account of a fracture in the specimen at the place where it should have occurred had one been present.

Thus, according to STERZEL, the ramification of the frond arises through a series of false dichotomies. The pinnule-bearing pinnæ are given off from these arms.

Two specimens are given natural size at figs. 1 and 3, Pl. CIX. Fig. 1 shows part of a division of the frond bearing foliage pinnæ. These are alternate or sub-opposite, and the alternate pinnules increase gradually in size from the base to about the middle of the pinnæ, whence they decrease as traced towards its apex. On the lower pinnæ the pinnules have four or six rounded lobes separated by a sinus which extends inwards about half the distance to the midrib (Pl. CIX, fig. 1*a*). On the middle-placed pinnæ of this specimen, the lobes on the pinnules become less prominent until, on the uppermost pinnæ, the pinnules have only sinuous margins or are entire. At the extreme apex the pinnæ assume the form of pinnules.

On fig. 3, Pl. CIX, the pinnules are broadly oblong, decurrent, and united to each other by a narrow wing, and have entire or slightly sinuous margins. A pinnule is enlarged three and a half times at fig. 3*a* to show their form and nervation. This example probably held a position on a pinna corresponding to that seen towards the upper end of the specimen given at fig. 1, with which the pinnules agree in form.

Both microsporangia and seeds in organic connexion with the frond have been discovered and described by GRAND'EURY, and I am indebted to him for both fertile and sterile specimens of this interesting plant. In regard to the micro-sporangia, he says that he was very successful in discovering at the extremity of several fronds of *Pecopteris Pluckeneti* bearing their foliage, in the place of receptacles, star-like groups of very carbonaceous anthers. Numerous fertile examples of this fern enabled him to determine, even in this singular *Pecopteris*, that the male flowers were not borne on the same fronds as the Seeds.*

On one of the specimens received from M. GRAND'EURY, some microsporangia are seen. The star-like group is not complete, but the part shown gives a good idea of its structure and that of the microsporangia. It is seen at *a*, fig. 4, Pl. CIX.

TEXT-FIG. 35.—*Dicksonites Pluckeneti* Schlotheim sp. Two pinnules with seeds attached to the tips of their segments. Enlarged three times. (Copied from ZEILLER.)

Text-fig. 35 shows two pinnules enlarged three times with seeds attached to the tips of the lateral lobes. The seeds are small, oval, slightly pointed at the upper end, and surrounded by a narrow wing, and have been pendent from the margin of the pinnule. They attain a size of about 3·5 mm. Their general form is that of a small *Samaropsis*.

When the seeds fall from the pinnules, they leave a small cup-like depression surrounded by a raised band with a small point in the centre (text-fig. 36). When these were first discovered, they were supposed by STERZEL to resemble the cup-like structure that surrounds the sorus of *Dicksonia*.

* *C. R. Acad. Sci. Paris*, vol. cxliii, p. 674, 19th Nov. 1906.

Hence the name *Dicksonites* which he gave to the new genus he created for the reception of the plant. These cup-like structures, however, are small pits to which the seeds were attached ; on the upper surface of the pinnules they appear as little mamilla-like projections. A small specimen exhibiting these mammillate projections on its upper surface is given natural size at fig. 2, Pl. CIX, and enlarged two times at fig. 2*a*. They are very small, and correspond in their position to that of the seeds at the extremities of the veinlets close to the margin of the pinnule. Enlarged photographs are given of some of these at figs. 2*b*, 2*c*, and 2*d*. They show a small depression at their apex, which seems to correspond to the small central point seen within the cup on the lower surface of the pinnule. This specimen, which is the only fertile British example of *Dicksonites Pluckeneti* Schlotheim I have seen, I received from the late EDWIN WILSON of Bristol.

TEXT-FIG. 36.—*Dicksonites Pluckeneti* Schlotheim sp. Under surface of pinnule showing small cup-like depression from which a seed has been removed. Enlarged three times. (Copied from ZEILLER.)

M. GRAND'EURY appears to have regarded the seeds he described as *Carpolithes granulatus* * to be those of *Dicksonites Pluckeneti*, and the specimens I received from him as isolated seeds of that plant (Nos. 3871 and 3872) have the characteristic blunt apiculæ of *Carpolithes granulatus* on their outer surface. But on the specimens received from him, which show the seeds in association with the frond, the outer surface is smooth and, so far as I have been able to observe in the seed-bearing examples he figures,† the seeds there also appear to have had a smooth outer surface. I have some doubt therefore whether *Carpolithes granulatus* is the seed of *Dicksonites Pluckeneti*. GRAND'EURY'S figures of them are also somewhat larger than the seeds found in organic union with *Dicksonites Pluckeneti*.

Distribution.—Dicksonites Pluckeneti Schlotheim sp. is rare in Britain and is restricted to the Radstockian Series.

RADSTOCKIAN SERIES.

SOMERSET AND BRISTOL COALFIELD.

RADSTOCK GROUP.

Horizon: ?. *Localities:* Somerset: Ludlow's Pit, Radstock; Kilmersdon Colliery, near Radstock; Welton Colliery, near Radstock; Braysdown Colliery, near Radstock; Upper Conygre Pit, Timsbury, 2½ miles N.N.W. of Radstock.

FARRINGTON GROUP.

Horizon: ?. *Localities:* Somerset: Foxcote, near Radstock; Farrington Pit, Farrington Gurney, 7½ miles north of Shepton Mallet.

* *Loc. cit.*

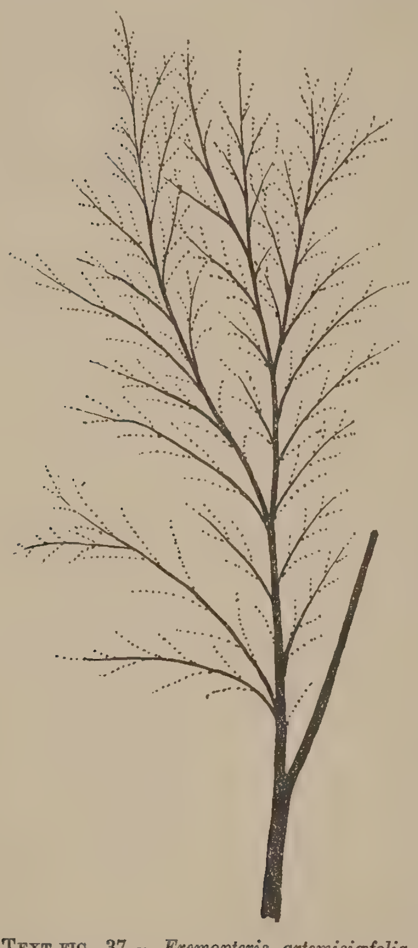
† *Comptes rendus*, vol. clx, p. 920.

Genus **Eremopteris** Schimper.

1869. *Eremopteris* Schimper, " Traité de paléont. végét.," vol. i, p. 416.

1879. *Eremopteris* Schimper in Zittel, "Handb. d. Palaeontologie," Abth. 2, "Palaeophytologie," p. 113.

Description.—Petiole dichotomizing at an acute angle; the two resulting forks may remain single, or one or both undergo further dichotomies. Rachis winged, smooth or more or less distinctly striated. Penultimate (? primary) pinnæ simple, occasionally bifurcated at an angle of about 45°, oblong, lanceolate, or deltoid-lanceolate, opposite, sub-opposite, or alternate. Pinnules opposite, sub-opposite, or alternate, attached by a broad footstalk. Those on basal portion of lower-situated pinnæ decurrent, with rhomboidal contour, and divided into four or five equilateral or sometimes inequilateral lanceolate or spathulate spreading segments, of which the terminal lobe is larger than the others. Pinnules on upper portion of penultimate pinnæ, and on pinnæ towards the apex of the sections of the frond, decurrent, lanceolate, or spathulate, equilateral, with blunt points, very frequently inequilateral, with rounded oblique apices; attached to rachis by a wide base, or more or less united to each other, or to the base of the terminal lobe; entire or with a few tooth-like lobes.



Text-fig. 37.—*Eremopteris artemisiæfolia* Sternberg sp. Diagrammatic representation of half a frond, showing dichotomy of petiole and pinnæ. The dotted lines represent the position of the pinnules.

Nervation.—A single broad vein passes into the fully-developed pinnules situated on the lower ultimate pinnæ (Pl. CXL, fig. 3), and divides into two arms in the wing formed by the decurrent pinnules; at a short distance within the base of the pinnule each arm again divides. Through subsequent dichotomies each segment of the pinnules has from four to ten or more almost parallel veinlets, the number varying according to the width of the segment. In the upper, smaller, frequently inequilateral, entire, or feebly-lobed pinnules (Pl. CXIII, figs. 3, 3*a*) two or more veins enter from the rachis, and immediately dichotomize at an acute angle, the two arms keeping close together; subsequent dichotomies are similar. The pinnules have no principal mid-vein. All the veins are of equal strength and arise through dichotomous division of the entering vein or veins.

The genus almost certainly belongs to the Pteridospermeæ, but seeds have not been found in organic connexion with the fronds.

Remarks.—The genus *Eremopteris* is easily distinguished from *Sphenopteris* by the absence of a prominent midvein in the pinnules from which lateral veins are given off. In the arrangement of the veinlets it approaches more to that of *Sphenopteridium*, but differs in the form of the pinnules. Among the Carboniferous plants the sporadic manner in which the pinnæ dichotomize, and the extent to which this takes place, seem to be peculiar to *Eremopteris artemisiæfolia*. A diagrammatic restoration of half a frond of this species is given at text-fig. 37. The central vascular bundle of the pinnæ seems to be formed of a number of thread-like strands which lie parallel to each other, and the strand or strands passing down the rachis from the pinnules also run parallel to the central band and remain free and distinct from it for some distance; whether they subsequently join on to the central band could not be determined from our specimens. A transverse section of such a rachis must have had an appearance very similar to a transverse section of a small rachis of *Myeloxylon*, a structure characteristic of the Pteridospermeæ.

The distinctive characters of the genus *Eremopteris* do not seem to be well understood by palæobotanists, for several species have been placed in it which do not appear to possess its generic characters.

In regard to the American species which have been included in *Eremopteris*, Dr David White says: "In the American Palæozoic flora the genus *Eremopteris* was given a broad interpretation by Lesquereux, so as to include a number of species referred by other authors to *Sphenopteris*, *Asplenites*, and *Rhacopteris*,"* but the genus so treated ceases to have any definite signification. As I have restricted it here, *Eremopteris* contains very few species.

Distribution.—So far as its distribution in Britain is concerned, the genus *Eremopteris* is restricted to Upper Carboniferous rocks, where it occurs in the Lanarkian Series and Westphalian Series.

Eremopteris artemisiæfolia Sternberg sp.

Plate CXI, figs. 1–4; Plate CXIII, figs. 1–3*a*; text-figs. 37, 38.

1826. *Sphenopteris artemisiæfolia* Sternberg, "Essai flore monde prim.," vol. i, fasc. iv, p. xv, pl. lvi, fig. 1; vol. ii, fasc. v–vi, p. 58, 1833. (Including vars. *tripartita*, *dichotoma*, and *minor*.)
1828. *Sphenopteris artemisiæfolia* Brongniart, "Prodrome," p. 50.
1829. *Sphenopteris artemisiæfolia* Brongniart, "Hist. des végét. foss.," vol. i, p. 176, pl. xlvi; pl. xlvii, figs. 1–2.
1848. *Sphenopteris artemisiæfolia* Sauveur (*pars*), "Végét. foss. des terr. houil. Belgique," pl. xx, fig. 3 (*non* figs. 1–2).
1836. *Gleichenites artemisiæfolius* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 184.
1845. *Gleichenites artemisiæfolius* Unger, "Synop. plant. foss.," p. 39.
1869. *Eremopteris artemisiæfolia* Schimper, "Traité de paléont. végét.," vol. i, p. 416, pl. xxx, fig. 5.
1877. *Sphenopteris* (*Eremopteris*) *artemisiæfolia* Lebour, "Illustr. of Fossil Plants," pl. xxxiii.
1879. *Eremopteris artemisiæfolia* Lesquereux, "Coal Flora," p. 293, pl. liii, figs. 5–6.
1883. *Eremopteris artemisiæfolia* Lesquereux, "Indiana Dept. of Geol. and Nat. Hist., 13th Ann. Rept.," pt. 2, *Palæont.*, p. 69, pl. xv, fig. 5.

* *Monographs U.S. Geol. Survey*, vol. xxxvii, "Fossil Flora of the Lower Coal Measures of Missouri," p. 16, 1899.

1899. *Eremopteris artemisiæfolia* Potonié, "Lehrb. d. Pflanzenpal.," p. 143, fig. 139.
1909. *Eremopteris artemisiæfolia* Gothan, *Monatsber. deutsch. geol. Gesellsch.*, vol. lxi, No. 7, p. 317.
1917. *Eremopteris artemisiæfolia* Seward, "Fossil Plants," vol. iii, p. 170, fig. 443.
1921. *Eremopteris artemisiæfolia* Gothan in POTONIÉ's "Lehrb. d. Paläobotanik," (Zweite Auflage), p. 87, fig. 79.
1826. *Sphenopteris stricta* Sternberg, "Essai flore monde prim.," fasc. iv, p. xv, fig. 3; vol. ii, p. 57, 1833.
1828. *Sphenopteris stricta* Brongniart, "Prodrome," p. 50.
1829. *Sphenopteris stricta* Brongniart, "Hist. des végét. foss.," p. 208, pl. xlviii, fig. 2.
1832. *Sphenopteris crithmifolia* Lindley and Hutton, "Fossil Flora," vol. i, pl. xlvi.
1836. *Gelichenites crithmifolius* Göppert, "Syst. fil. foss." (*loc. cit.*), p. 185.
1845. *Gelichenites crithmifolius* Unger, *loc. cit.*, p. 40.
1833. *Sphenopteris Brongniarti* Sternberg, "Essai flore monde prim.," vol. ii, fasc. v–vi, p. 57.
1836. *Hymenophyllites Brongniarti* Göppert, "Syst. fil. foss." (*loc. cit.*), p. 258.
1845. *Hymenophyllites Brongniarti* Unger, "Synop. plant. foss.," p. 70.
1877. *Sphenopteris* sp. Lebour, "Illustr. of Fossil Plants," pls. xxxiv, xxxv, xxxvi.
(? Date) *Asplenioides obtusum* König, "Icones foss. sectiles," pl. xvi, fig. 199.

Description.—Pteridosperm ?. Main rachis and more rarely those of the pinnæ bifurcate at an acute angle, smooth or showing longitudinal striations. Resulting sections of frond bipinnate. Ultimate pinnæ lanceolate to deltoid, according to their position on pinna, opposite, sub-opposite, or alternate, forming an angle of about 45° with the rachis from which they spring. Pinnules alternate, sub-opposite, or opposite, and springing from the rachis at an angle of about 45°; those situated at the base of the pinna deltoid and divided into four or five elliptical or lanceolate spreading segments with obtuse points, entire or bearing one or two short obtuse lobes. In the more divided pinnules the lower segments are free and the upper united to the terminal lobe, which is elliptical or broadly lanceolate with obtusely pointed apex, entire, or with one or two short lateral lobes. Upper pinnules with fewer and less prominent opposite or sub-opposite lobes, free or united to the base of the terminal lobe; terminal pinnules broadly lanceolate, more or less united to each other or to the base of the terminal pinnule.

Nervation.—Two or more veins enter the pinnule from the rachis. These immediately dichotomize at an acute angle, the two arms keeping close together, as also in subsequent dichotomies. The basal portions of the dichotomies have thus the appearance of the veins passing out in pairs until the arms of the fork become more separated.

The vascular bundle passing up the centre of the rachis is formed of a number of thread-like strands; these do not appear to provide the veins immediately to the pinnules, but the strands that enter them are seen, for some distance before they do so, as separate strands in the rachis and parallel with those of the central composite vascular bundle. Their downward course in the rachis can be traced for a considerable distance and they appear subsequently to form a part of the central bundle of strands, although they retain their individual identity. Whether they united at a lower level with any of the central group of strands could not be determined. All the veins in the pinnules are of equal strength.

In the upper simple and frequently inequilateral pinnules there is the appearance of a midrib in their basal portion, but this is caused by several veins lying close together; gradually they separate, bend outwards, and supply the upper part of the pinnule. The lower lateral portion is supplied by other veins which enter parallel with the central group but diverge to the broader side of the limb in the inequilaterally-formed pinnules and supply it with veinlets. The extreme base of the pinnule is thus occupied by a band of free but closely-placed veins.

Remarks.—A fragment of a frond of *Eremopteris artemisiæfolia* Sternberg sp. is given on Pl. CXI, fig. 3, natural size. On this example the pinnules are generally divided into three lanceolate segments of unequal width, the two lateral being narrower than the terminal segment. The width of the pinnule-segments varies much on different specimens, as can be observed on the figures given here. On the specimens seen at figs. 1 and 2 the pinnule-segments are broader. That at fig. 1 shows a dichotomously-divided penultimate pinna (? primary), and the example at fig. 2 an undivided one. The occurrence of dichotomy in the frond of *Eremopteris artemisiæfolia* seems to have taken place in a sporadic manner. Another dichotomy of a pinna is seen at fig. 3, Pl. CXIII. The pinnules on this small example are very obtuse and show the nervation with exceptional clearness (Pl. CXIII, fig. 3A). From this specimen the foregoing description of the veins has been taken.

TEXT-FIG. 38.—*Eremopteris artemisiæfolia* Sternberg sp. Rhizome or stem, with fragments of fronds. Specimen in the "Hutton Collection," Hancock Museum, Newcastle-on-Tyne, No. 34*b*. Two-thirds natural size. (Copied from SEWARD'S "Fossil Plants," vol. iii, p. 170.)

The central band of vascular strands in the rachis, and those that pass from it into the pinnule, lie parallel with each other and impart to the surface of the rachis an appearance of longitudinal striation.

The type of BRONGNIART'S *Sphenopteris stricta* is preserved in the Hunterian Museum, Glasgow University. The "strict" character is somewhat exaggerated in the figure, and the plant is only a form of *Eremopteris artemisiæfolia*.

With *Eremopteris artemisiæfolia* must also be united the *Sphenopteris crithmifolia* L. and H. It differs from the type only in being smaller in all its parts and in having narrower pinnule-segments. A small example of this form is shown natural size on Pl. CXIII, fig. 2. In the Hancock Museum (Newcastle-on-Tyne) a specimen of the *crithmifolia* form of the plant, from the Sensham Seam, Jarrow, shows part of a stem or rhizome 10 cm. in length, to the apex of which are attached a few petioles, but very few of the pinnules have been preserved. At text-fig. 38 a reduced sketch of this specimen is reproduced from SEWARD's "Fossil Plants," vol. iii, p. 170, fig. 443.

The scars from which the fronds have fallen are seen on the fossil.

The constant occurrence of *Samaropsis acuta* L. and H. sp.* with *Eremopteris artemisiæfolia* points most strongly to the probability of these small seeds being those of that plant. It is almost impossible to collect *Eremopteris artemisiæfolia* without also finding *Samaropsis acuta* in the same bed. Few specimens of *Eremopteris artemisiæfolia* fail to show some examples of it on the same slab. Professor OLIVER has called my attention to the occurrence of small star-like cupules associated with these seeds, and I have no doubt that they belong to each other. This constant association of *Samaropsis acuta* with *Eremopteris artemisiæfolia* cannot be a mere accident, and I have little doubt that these seeds are those of *Eremopteris artemisiæfolia*, which in all probability belongs to the Pteridosperms. The numerous isolated vascular strands which form the vascular system of the petioles reminds one much of the arrangement of the strands in the petioles of *Myeloxylon.*

STERNBERG gives "Yawdon in Northumberland" as the locality for the type specimen of *Eremopteris artemisiæfolia.* This is evidently a mistake for "Fawdon," a known locality for the species.

Distribution.—Although *Eremopteris artemisiæfolia* occurs in several of our coalfields of both Westphalian and Lanarkian age it is by no means a common species. The greater number of the specimens in our museums have come from the Northumberland and Durham Coalfield, where in years past it seems to have been found fairly commonly, though at present it seems to be as rare there as in other British Coalfields.

WESTPHALIAN SERIES.

NORTH STAFFORDSHIRE COALFIELD.

Horizon: ?. *Locality:* Fenton.

NORTHUMBERLAND AND DURHAM COALFIELD.

Northumberland.—*Horizon:* High Main Seam. *Localities:* Gosforth (Hancock Museum, Newcastle-on-Tyne); Fawdon, 3 miles north-west of Newcastle-on-Tyne.

Horizon: Low Main Seam. *Locality:* Cramlington (J. SIM).

Durham.—*Horizon:* Bensham Seam. *Locality:* Jarrow Colliery, Jarrow (Hancock Museum).

Horizon: Maudlin Seam. *Locality:* Springwell Colliery, Springwell, 3 miles south-east of Gateshead (J. T. STOBBS).

Horizon: Stone Coal. *Locality:* Chopwell Colliery, 2½ miles north-east of Ebchester (P. CHARLTON).

* *Cardiocarpum acutum* L. and H., "Fossil Flora," vol. i, pl. lxxvi.

South Staffordshire Coalfield.

Horizon : Blue Measures, 6 feet above Fireclay Coal. *Locality :* Netherton, near Dudley.

North Derbyshire and Nottingham Coalfield.

Horizon : ?. *Locality :* Clay Cross (Rev. J. M. Mello).

South Wales Coalfield.

Horizon : ?. *Locality :* Beaufort and Prince of Wales' Pit, Abercarn.

LANARKIAN SERIES.

Ayrshire Coalfield.

Horizon : Shale over Stranger Coal. *Locality :* Grange Colliery, Kilmarnock.

Canonbie Coalfield.

Horizon : Main Coal. *Locality :* Blinkbonny Pit, Rowanburn, Dumfriesshire.

Fife Coalfield.

Horizon : Roof of Chemiss Coal. *Localities :* Leven Colliery, Leven (J. W. Kirkby); Durie Colliery, Leven (J. W. Kirkby).

Lanarkshire Coalfield.

Horizon : Ell Coal. *Locality :* Pit, ½ mile east of Baillieston (Collection of Geological Survey, Edinburgh).

Horizon : Kiltongue Coal. *Locality :* Souterhouse, near Coatbridge (R. Dunlop).

Horizon : Main Coal. *Locality :* Pit near Carmyle, 1 mile north of Cambuslang (Collection of Geological Survey, Edinburgh).

Horizon : ?. *Localities :* Howlit Glen, Crossford, Lesmahagow; Farme Colliery, Rutherglen (type of *Sphenopteris stricta* Brongt., Hunterian Museum, Glasgow University); Bothwell; Carluke.

Midlothian Coalfield.

Horizon : ?. *Localities :* Dalkeith Palace Grounds, east bank of River South Esk, 200 yards above junction with River North Esk (Collection of Geological Survey, Edinburgh); River South Esk, in Dalkeith Park, left bank, ⅙ mile south-west of Smeaton Bridge (Collection of Geological Survey, Edinburgh); River South Esk, left bank at point south-west of Newmills Bridge and west of Brewlands, Dalkeith (Collection of Geological Survey, Edinburgh).

Eremopteris zamioides Bertrand.

Plate CXI, figs. 5, 5*a*, and 6.

1910. *Sphenopteris zamioides* P. Bertrand, " Description des Végétaux houillers, Mines de Bruay," *Ann. Soc. géol. du Nord*, vol. xxxix, p. 361, pl. iv, figs. 6, 7.

Description.—Frond bipinnate, or tripinnate. Penultimate and ultimate rachises straight, with a furrow on the upper surface and a corresponding semicylindric ridge on the dorsal surface, winged and longitudinally striated. Ultimate pinnæ oblique to rachis, lanceolate, opposite, sub-opposite, or alternate. Pinnules springing from the rachis at an acute angle, opposite, sub-opposite, or alternate, lanceolate, entire, slightly narrowed towards the base, decurrent, and terminating on a sharp or obtuse point. The uppermost pinnæ assume the form of long entire pinnules.

A single flat vein appears to enter each pinnule and through one or two dichotomies supplies a few parallel veinlets of equal strength to each pinnule.

Remarks.—I have seen only three fragmentary examples of this species, of which two are shown natural size at figs. 5–6, Pl. CXI. That given at fig. 5 may be the termination of a frond or of a penultimate pinna. The lower ultimate pinnæ bear decurrent, sub-alternate, entire pinnules, united to each other by the wing, which forms a margin to the rachis. They are narrowly lanceolate and end in a slightly obtuse point. This is seen in the three pinnæ enlarged two times at fig. 5*a*. The small fragment seen natural size at fig. 6 is from a lower region of a penultimate pinna. The pinnules on this example are also connected to each other by the decurrent wing, are broader than those seen on fig. 5, contract slightly downwards from about the middle, and have obtuse apices.

The nervation is not very distinctly seen at the base of the pinnules, but a single broad flat vein seems to enter each pinnule, at the base of which it immediately divides ; the resulting two arms again dichotomize and provide the pinnule with four parallel veins. The vein entering the pinnule seems to pass down the rachis some distance as a free strand, but on account of the state of preservation of the specimen its subsequent course could not be followed.

Professor P. Bertrand placed his plant in the genus *Sphenopteris* on account of the generic description of *Eremopteris* given by Zeiller,* who says that the principal character which distinguishes *Eremopteris* from *Sphenopteris* is that their pinnules are simple and not lobed ; they are oblong and contracted at base in the form of a wedge, decurrent, and rounded or more or less oblique at the summit.

In *Eremopteris artemisiæfolia*, the type of the genus, the pinnules are lobed or simple, equilateral or inequilateral, and end in straight, slightly obtuse or more or less obliquely obtuse points. This is well seen on our figures of *Eremopteris artemisiæfolia* given on Pl. CXI, and on the small example of *Eremopteris artemisiæfolia* seen on Pl. CXIII, fig. 3. That the pinnules be simple is not a necessary character of the genus, since simple lanceolate pinnules and pinnules with lanceolate segments occur

* " Flore foss. terr. houil. de Commentry," p. 72.

also on the fronds. These variations in the form of the pinnule and pinnule-segments are well seen on the specimens figured by BRONGNIART on his pls. xlv and xlvi. The whole build of the frond of *Sphenopteris zamioides* agrees so well with that of *Eremopteris* that I see no reason for excluding it from that genus.

For my specimens of *Eremopteris zamioides*, my thanks are due to Mr W. HEMINGWAY, by whom they were collected.

Distribution.—Very rare, and known from only one locality in the Westphalian Series.

WESTPHALIAN SERIES.

YORKSHIRE COALFIELD.

Horizon: Shale over Ackworth Rock. *Locality:* Cadeby Colliery Sinking, Conisborough (W. HEMINGWAY).

Genus **Aneimites** Dawson.

1860. *Cyclopteris* subgenus *Aneimites* Dawson, *Quart. Journ. Geol. Soc.*, vol. xvii, p. 5.
1874. *Aneimites* Schimper, " Traité de paléont. végét.," vol. iii, p. 489.
1869. *Triphyllopteris* Schimper, " Traité de paléont. végét.," vol. i, p. 478.
1879. *Triphyllopteris* Schimper in ZITTEL, " Handb. d. Palaeont.," Abth. 2, " Palaeophytologie," p. 114.
1921. *Triphyllopteris* Gothan in POTONIÉ, " Lehrb. d. Paläobot." (Zweite Auflage), p. 78.

Description.—Frond of large size (in one if not the other members of the genus), ramifying by a series of dichotomies, petiole broad and longitudinally striated. Pinnules large, attaining a length of 4 cm., but usually much smaller, pyriform, and when undivided the sides below the rounded apex are slightly convex and gradually narrow into a stout footstalk ; when segmented, the segments are ovate or pyriform with rounded apices, more or less deeply separated by an acute sinus. Veins of equal strength, radiating from the base of the pinnule and dichotomizing several times in their course to the margin.

Remarks.—It is very difficult to assign a satisfactory systematic position to the plants included in the genus *Aneimites*. They have been placed by different investigators in *Nœggerathia*, *Cyclopteris*, and *Adiantites*. The ramification of the frond separates it from *Nœggerathia*. *Cyclopteris* is now generally employed for the reception of the isolated protective aphlebioid pinnules which occur on the petiole or rachis of some species of *Neuropteris* and perhaps also of *Odontopteris*, but which cannot be referred to their parent plants. These pinnules are usually of a circular or reniform shape and their sides are not concave at the base or contracted into a stout petiole. With *Adiantites*, however, the pinnules have a great similarity in form and nervation, but the ramification of the frond seems to have been dissimilar. The pinnules of *Aneimites*, moreover, vary greatly in size, a variation not seen in those of *Adiantites*, which also never attain to the size of those of *Aneimites*. When expressed in writing these differences do not appear to be of much distinctive importance ; nevertheless, when specimens of *Aneimites* are examined, they possess a recognisable character which is difficult to describe verbally.

That the genera *Aneimites* Dawson and *Triphyllopteris* Schimper are synonymous is shown by the fact that Schimper * included *Aneimites Acadica* Dawson, the type of the genus, in his *Triphyllopteris*. Since DAWSON's genus antedates *Triphyllopteris* the name *Aneimites* is adopted here.

All the specimens belonging to the genus *Aneimites* yet discovered have been in a fragmentary condition, though the type of the genus (*Aneimites Acadica* Dawson) is plentiful at Horton, and has been collected at other localities in Canada, where it is characteristic plant in Lower Carboniferous rocks.

Both DAWSON and SCHIMPER associated with their respective genera *Aneimites* and *Triphyllopteris*, as the fertile portion, circinately or scorpioidally twisted rachises which do not bear any foliage pinnules. At the extremities of these rachises SCHIMPER found sporangia which he describes as sori (sporangia ?) forming a grape-like bunch, round, finely granular, and in no case to be compared with the sporangia of *Aneimia*, with its apical annulus.† The specimen bearing sporangia, described by SCHIMPER, does not appear to have had any organic connexion with the sterile specimens to which he referred it as its fertile condition. DAWSON also figures a similar form of pinna, which he referred to his *Aneimites Acadica* as its fertile condition. In neither case, however, were these sporangia-bearing pinnæ found in organic connexion with the pinnæ-bearing foliage pinnules. Hence the only ground on which these circinately twisted pinnæ are regarded as the fertile condition of these plants, is that of association. Their proposed union is therefore not based on satisfactory evidence, although it may eventually prove to be correct. In these circumstances, I have omitted from the generic characters given above all reference to these fertile pinnæ.

The scorpioidally twisted pinnæ, described by DAWSON and SCHIMPER, seem to be indistinguishable from the similarly twisted fertile pinnæ of *Alcicornopteris*, but in that genus the foliage pinnules assume the form of aphlebia-like expansions.

DAWSON compared his genus *Aneimites* with the existing fern-genus *Aneimia*, with which he believed it to be related. This presumed relationship, however, is very improbable ; it is much more likely that the plants included in *Aneimites* are pteridosperms.

Distribution.—The genus *Aneimites* is characteristic of Lower Carboniferous rocks.‡

Aneimites Acadica Dawson.

Plate CX, figs. 4, 5, 6, 7.

1858. *Næggerathia Bockschiana* Lesquereux (*non* Göppert) in ROGERS, "Geol. of Pennsylvania," vol. ii, pt. 2, p. 854, pl. iii, figs. 1, 1*a*–1*d*.

1880. *Archæopteris Bockschiana* Lesquereux (*non* Göppert), "Coal Flora," p. 306, pl. xlix, figs. 1–4.

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* Schimper in ZITTEL, "Handb. d. Palaeont.," Abth. 2, "Palaeophytologie," p. 115.

† *Triphyllopteris Collombi* Schimper in ZITTEL, *loc. cit.*, p. 114, fig. 87.

‡ I exclude from this genus *Cyclopteris rhomboidea* Ettingshausen, which has been included in it by SCHIMPER. ("Steinkohlenflora von Stradonitz in Böhmen," *Abhandl. k. k. geol. Reichsanstalt*, Band i, Abth. 3, No. 4, p. 12, pl. ii, fig. 5, 1852.)

1871. *Cyclopteris* (*Aneimites*) *Bockshii* Dawson (*non* Göppert), "Foss. Plants Devon. and Upper Silur. Form. of Canada (*Geol. Survey of Canada*), p. 48.
1860. *Cyclopteris* (*Aneimites*) *Acadica* Dawson, *Quart. Journ. Geol. Soc.*, vol. xvii, p. 5.
1865. *Cyclopteris* (*Aneimites*) *Acadica* Dawson, *Quart. Journ. Geol. Soc.*, vol. xxii, p. 153, pl. viii, figs. 32, 32*a*–32*i*.
1868. *Cyclopteris Acadica* Dawson, "Acadian Geology" (2nd ed.), p. 252, fig. 75.
1873. *Cyclopteris* (*Aneimites*) *Acadica* Dawson, "Rept. Foss. Plants Lower Carb. and Millstone Grit Form. Canada." (*Geol. Survey of Canada*), p. 26, pl. vii, figs. 53–63.
1874. *Aneimites acadicus* Schimper, "Traité de paléont. végét.," vol. iii, p. 489.
1879. *Triphyllopteris acadica* Schimper in Zittel, "Handb. d. Palaeont.," Abth. 2, "Palaeophytologie," p. 115.
1862. *Cyclopteris Collombiana* Schimper in Koechlin-Schlumberger, "Terr. d. Transition des Vosges," p. 339, pl. xxvii, figs. 8–10 (Excl. ref. *Cyclopteris Rœmeriana* Göppert).
1869. *Triphyllopteris Collombiana* Schimper, "Traité de paléont. végét.," p. 479, pl. cvii, fig. 13.
1879. *Triphyllopteris Collombi* Schimper in Zittel, "Handbuch d. Palaeontologie," Abth. 2, "Palaeophytologie," p. 114, fig. 87.
1921. *Triphyllopteris Collombiana* Gothan in Potonié's "Lehrb. der Paläobotanik" (Zweite Auflage), p. 79.

Description.—Frond large, ramifying by a series of dichotomies. Petiole longitudinally striated. Pinnules pyriform, attaining a size of from 1 cm. to 4 cm. in length, entire, rounded at apex with slightly convex sides and gradually narrowing into a broad footstalk, or divided into two to five, but generally three, segments. Segments ovate with rounded apex, more or less deeply separated by an acute sinus, terminal lobe usually the largest. Veins of equal strength, radiating fan-like from the base and dichotomizing several times in their course to the margin.

Remarks.—Four small specimens of *Aneimites Acadica* Dawson are given natural size on Pl. CX, figs. 4–7. That seen natural size at fig. 4 is the most perfect example I have seen. It was collected by the late T. Ovens, of Foulden, and after his death was given to me by his father, to whom my thanks are due for the interesting specimen. It shows part of an ultimate pinna on which the alternate pinnules are more or less pyriform. The terminal pinnule has had a small obtuse lobe on one side, made more prominent by an accidental split which extends inwards for some distance. The uppermost lateral pinnule on the left has a distinct basal lobe, and is similar to that shown at the top of Lesquereux's fig. 1*b*, pl. iii.* The lowest pinnule on the right also shows a large basal lobe. The pinnules narrow at their base to form a broad footstalk. Their size varies from 2 cm. to 2·50 cm. in length.

The pinnules of the specimens given at figs. 5–6 are slightly smaller and have more distinctly developed segments. The trilobate pinnule at the upper end of fig. 5 is indistinguishable from some of those seen on Schimper's figures of *Triphyllopteris Collombiana,* especially with that on his pl. cvii, fig. 13.† It also agrees perfectly with the pinnules seen on the reduced figure of *Aneimites Acadica* given by Dawson,‡ and with specimens of the plant received from the late Sir William Dawson.

* In Rogers, "Geol. of Pennsylvania," *loc. cit.*

† "Traité de paléont. végét."

‡ *Quart. Journ. Geol. Soc.*, vol. xxii, pl. viii, fig. 32.

A fragment with small pinnules about 1 cm. in length is given natural size at fig. 6. These small pyriform pinnules have broad footstalks and correspond with some on the figure given by DAWSON * and by LESQUEREUX.†

When the epidermis is preserved on the smaller rachises they have a smooth outer surface, but when it has been removed by decay or imperfect preservation, they are longitudinally striated.

From a study of the figures of *Nœggerathia Bockschiana* Lesquereux (*non* Göppert), *Aneimites Acadica* Dawson, and *Triphyllopteris Collombiana* Schimper, as well as from an examination of authentic Canadian specimens of *Aneimites Acadica*, I have failed to observe any character by which the three plants mentioned above can be separated from one another. SCHIMPER'S *Triphyllopteris Collombiana* as figured by him appears to agree perfectly with DAWSON'S *Aneimites Acadica*, nor can I separate it from the *Nœggerathia Bockschiana* as figured by LESQUEREUX. The *Adiantites Bockschii* Göppert is probably founded on a *Cardiopteris* pinnule.‡

It is not necessary to refer here to the fertile pinnæ which have been referred to the plants described by DAWSON and SCHIMPER, as this has been already dealt with in the notes appended to the generic description of *Aneimites*.

Distribution.—Aneimites Acadica is very rare in Britain and restricted to the Cementstone Group of the Calciferous Sandstone Series.

CALCIFEROUS SANDSTONE SERIES.

CEMENTSTONE GROUP.

Horizon : Near base of the Cementstone Group. *Locality :* Left bank of Crooked Burn, about 50 yards below Newton Farm, Foulden, Berwickshire (the late T. OVENS).

Horizon : ?. *Localities :* Right bank of Whiteadder Water, ¾ of a mile below Allanton; Whiteadder Water, Bellsburn Scaur, near Chirnside, Berwickshire.

Genus **Macrosphenopteris** Kidston.

1888. *Macrosphenopteris* Kidston, "Foss. Flora of Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 353.

Description.—Simple fronds or large pinnules of delicate texture, provided with a stout midrib from which spring at an acute angle numerous lateral arcuate veinlets which dichotomize two or three times in their course to the sinuous or toothed margin.

Remarks.—This genus was instituted for the reception of *Adiantites Haidingeri* Ettingshausen § and *Macrosphenopteris Lindsœoides* described below.

* "Report Foss. Plants Lower Carb." (*loc. cit.*), pl. viii, fig. 56.

† In ROGERS, "Geol. of Pennsylvania," pl. iii, fig. 1*b*.

‡ *Adiantites Bockschii* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, p. 384, pl. xxxvi, fig. 6, 1836; *Cyclopteris Bockschii* Göppert, "Foss. Flora d. Silur. Devon. u. Unteren Kohlenform.," p. 77, pl. xxxviii, fig. 3, 1860.

§ "Steinkohlenflora von Radnitz," *Abhandl. k. k. geol. Reichsanst.*, Band ii, Abth. 3, No. 3, p. 34, pl. xix, fig. 3, 1854.

The genus *Macrosphenopteris* differs from both *Adiantites* and *Cyclopteris* in the presence of a strong midrib from which are given off the lateral veins.

Both the species included in the genus seem to be very rare, the British member being known from only one specimen.

The systematic position of *Macrosphenopteris* is undetermined.

Distribution.—The genus has been found only in the higher portion of the Upper Carboniferous Series.

Macrosphenopteris Lindsæoides Kidston.

Plate CX, figs. 3, 3*a*.

1888. *Macrosphenopteris Lindsœoides* Kidston, "Foss. Flora of Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 353, pl. xxvii, fig. 1.

Description.—Frond, or large pinnules with a strong median vein which gives off at an acute angle arcuate lateral veinlets that dichotomize several times in their course to the sinuous or dentate margin.

Remarks.—The only specimen of this species that I have seen is given on Pl. CX, fig. 3, natural size, and is here provisionally treated as being a portion of a large pinnule.

A strong midrib, about 0·75 mm. in breadth, lying in the shadow at the right side of the figure, passes up the pinnule and gives off at an acute angle numerous slender arcuate veins. The margin of the pinnule is sinuous with a few irregularly placed sharp teeth. At several places on the margin can be seen what seems to be a thickening of the tissue. This is shown distinctly on the figure, and a small portion of the thickened margin is enlarged two times at fig. 3*a*. It appears to be a definite structure and not formed by a simple bending over of the margin. So far as one can judge from the appearance of the fossil, the limb of the pinnule has been formed of a delicate tissue, but the marginal structure has a very appreciable thickness. What function this solid band of thickening performed I am unable to determine. It may be connected in some way with the fructification of the plant, but there is no satisfactory evidence to support this suggestion.

The only other Carboniferous plant of the same nature as that just described is *Adiantites Haidingeri* Ettingshausen,* but this differs from our species in its regularly toothed margin.

Ettingshausen believed his specimen to represent part of an undivided frond, but neither his example nor the specimen here described is sufficiently perfect to enable one to determine whether the fossils represent part of a large pinnule or portion of a single frond. He compared his plant with *Cyclopteris* and *Adiantites*, and placed it in the latter genus, but both *Adiantites* (*Macrosphenopteris*) *Haidingeri* Etting-

* "Steinkohlenflora von Radnitz" (*loc. cit.*), p. 34. See also Schimper, "Traité de paléont. végét.," vol. i, p. 427, 1869.

shausen and *Macrosphenopteris Lindsœoides* differ from these two genera in the presence of a strong midrib from which the lateral veinlets arise.

The systematic position of the plant is undetermined.

Distribution.—The only specimen of *Macrosphenopteris Lindsœoides* known to me is that figured here.

RADSTOCKIAN SERIES.

RADSTOCK GROUP.

Horizon : ?. *Locality :* Radstock, Somerset.

Genus **Alcicornopteris** Kidston.

1887. *Alcicornopteris* Kidston, "Fructification of some Ferns from the Carboniferous Formation," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 152.

1901. *Alcicornopteris* Vaffier, "Étude géol. et paléont. du Carbon. Infér. du Mâconnais," *Ann. Univ. de Lyon*, Nouv. Sér. i (Sci. et Méd.), fasc. 7, p. 122.

Description.—Petiole naked, gradually increasing in width from below upwards, dichotomizing at apex and dividing the frond into two sections. The rachises of each section again ramify through a series of dichotomies whose somewhat flattened branches are more or less convoluted.

Synangia terminal, large, campanulate, and composed of a number of microsporangia rather over 1 cm. in length, which stand upright, are united to each other by their bases, and attached to the margin of the disc-like enlarged apex of the rachis.

Foliage formed of a broad, pinnately divided, straight or convoluted aphlebioid expansion. Seeds unknown.

Remarks.—The much-convoluted fertile rachises have a similar appearance to the fructification which has been supposed to belong to *Aneimites Acadica* Dawson,* but these two plants differ in the form of the sterile pinnæ.

Distribution.—The genus *Alcicornopteris* has only been recorded from Lower Carboniferous Rocks.

Alcicornopteris convoluta Kidston.

Plate CVIII, figs. 1–6.

1883. *Rhacophyllum Lactuca* Kidston (*non* Schimper), "Fossil Plants in Eskdale and Liddesdale," *Trans. Roy. Soc. Edin.*, vol. xxx, p. 540.

1887. *Alcicornopteris convoluta* Kidston, "Fructification of Ferns from Carboniferous Formation," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 152, pl. viii, figs. 11–15.

1903. *Alcicornopteris convoluta* Kidston, "Fossil Plants of the Carboniferous Rocks of Canonbie, etc.," *Trans. Roy. Soc. Edin.*, vol. xl, p. 749.

Description.—Pteridosperm. Petiole dichotomizing at a wide angle, broadening upwards and becoming flat at the margins on the upper part, with an angular

* "Fossil Plants of Lower Carb. and Millstone Grit Formation" (*Geol. Survey of Canada*), p. 26, pl. vii, figs. 53–63, 1873.

median ridge. In the fertile fronds the two sections ramify by a further series of dichotomies, and the resulting divisions become circinately convoluted till a complete series of branches is produced, which frequently overlap each other. The lower or early divisions have flat wing-like margins with an angular ridge running up the middle, but as the divisions are traced outwards and the rachises become smaller, the wing-like flattening of their margins becomes less prominent or disappears, and the ultimate divisions assume a more or less round form.

The sterile pinnæ of the fronds possess broad foliaceous aphlebia-like expansions, cut into spirally bent or twisted lobes in which the dichotomously divided veins are frequently indicated by ridges on their upper surface.

Remarks.—At fig. 1, Pl. CVIII, is seen the upper end of a petiole which dichotomizes at a very open angle. It increases in width from the base upwards, and as the width increases it becomes flattened at the margins and has a more or less prominent median ridge. Immediately below the fork the petiole is 9 mm. in breadth. The arms of the dichotomy are also flattened and undergo further divisions which ultimately end in flat frondose expansions. This specimen represents the sterile condition of the frond. Two other sterile portions of fronds are given at figs. 2*b* and 6. That at fig. 2*b* shows the dichotomy of the petiole and the base of the two resulting sections of the frond, each of which is seen to dichotomize. Their rachises have an angular ridge with wing-like margins, and the divisions they give off bear frondose expansions. The rachises on this specimen are longitudinally striated, but when the epidermal tissues are preserved as a carbonaceous layer, the petiole and rachises are smooth. It seems that the rachis exhibits the longitudinal striations only when the epidermis is destroyed, as at fig. 2*b* ; these striations are probably caused by subepidermal strands of sclerenchymatous tissue. Another small frondose portion of a frond is given at fig. 6, which shows the helicoid twisting of the foliaceous segments.

The fragment given at fig. 3 has a smooth rachis whose flattened curved divisions have lost the frondose appearance of the specimens just described. The rachises are broad and flattened, however, and as the ultimate divisions end in short sharp points, a form of the sterile condition of the plant is probably represented.

The specimen seen at fig. 5, like all the other figures of the species given here, is natural size. The rachises of various degrees are broad and flat, with a smooth surface, but when examined with a lens exhibit fine hair-like striations that apparently are caused by the arrangement of the epidermal cells. The ultimate divisions are much convoluted, overlie one another, and bear no foliar expansions. The whole structure has been dense and rigid. The modification of the pinnæ on this example seem to indicate a fertile portion of the frond.

In fig. 4*b* the convoluted divisions of the frond are more narrow, smaller, less flattened, and usually terminate in truncate ends. It therefore seems probable that to these ultimate divisions were attached some form of fructification. This specimen shows the smallest sized branchlets of the species which I have seen. They are slightly flattened, and have assumed the form of naked pinnæ. There seems to have been a transition from the sterile to the fertile pinnæ, by a gradual suppression of the foliar organs.

The convoluted naked pinnæ, especially such as seen at fig. 4*b*, have a considerable resemblance to the scorpioidal or curved pinnæ of the sporangia-bearing portion of fronds which have been supposed to be the fertile pinnæ of *Triphyllopteris Collombiana* Schimper,* and *Aneimites Acadica* Dawson,† but *Alcicornopteris convoluta* differs from these plants in its curious aphlebia-like sterile pinnules, which in *Triphyllopteris Collombiana* Schimper and *Aneimites Acadica* Dawson are of the *Aneimites* type.‡

Distribution.—Alcicornopteris convoluta is not uncommon in the Cementstone Group of the Calciferous Sandstone Series. It also occurs in the Oil-Shale Group, but is very rare on that horizon.

CALCIFEROUS SANDSTONE SERIES.

OIL-SHALE GROUP.

Dumfriesshire.—*Horizon:* Beds correlated with the Scremerston Coals. *Locality:* Archerbeck, above Millsteads, Canonbie (Collection of Geological Survey, Edinburgh).

Roxburghshire.—*Horizon:* Beds correlated with the Scremerston Coals. *Locality:* Kershope Burn, near Head (Collection of Geological Survey, Edinburgh).

CEMENTSTONE GROUP.

Berwickshire.—*Horizon:* ?. *Localities:* Whiteadder Water, Broomhouse Burn, near Duns (Collection of Geological Survey, Edinburgh); Shore, ½ mile east of Cove Harbour, 1½ mile north-east of Cockburnspath (Collection of Geological Survey, Edinburgh); Right bank of Whiteadder Water, ¾ mile below Allanton (Collection of Geological Survey, Edinburgh); North bank of Whiteadder Water, between Edington Mill and Hutton Bridge, about 6 miles west of Berwick (J. H. Craw); Lennel Braes, scaur on south-east side of Churchyard, ¼ mile north-east of Lennel Village (Collection of Geological Survey, Edinburgh).

Cumberland.—*Horizon:* ?. *Locality:* Bull Cleuch, Kirk Beck, Bewcastle (Collection of Geological Survey, London).

Dumfriesshire.—*Horizon:* Ballagan Beds. *Locality:* Docken Burn, Eskdale, 3 miles south of Langholm (Collection of Geological Survey, Edinburgh).

Haddingtonshire.—*Horizon:* Ballagan Beds. *Localities:* Shore, 1 mile east of Tynninghame Links, near mouth of River Tyne (Collection of Geological Survey, Edinburgh); Shore between St Baldred's House and Seacliff House, east of Tantallon Castle, North Berwick (Collection of Geological Survey, Edinburgh).

* "Traité de paléont. végét.," vol. i, p. 479, 1869; *Triphyllopteris Collombi* Schimper in Zittel, "Handbuch d. Palaeont.," Abth. ii, "Palaeophytologie," Lief. i, p. 114, fig. 87, 1879.

† *Cyclopteris* (*Aneimites*) *Acadica* Dawson, *Quart. Journ. Geol. Soc.*, vol. xxii, p. 153, pl. viii, fig. 32, 1865; "Rept. Fossil Plants Lower Carboniferous and Millstone Grit of Canada," *Geol. Survey of Canada*, p. 26, pl. vii, figs. 53–63, 1873.

‡ See remarks under *Aneimites*, p. 413.

Horizon : ?. *Localities :* Belhaven Bay, $1\frac{1}{2}$ miles west of Dunbar (Collection of Geological Survey, Edinburgh); Long Craig's Bay, east of Dunbar (Collection of Geological Survey, Edinburgh).

Northumberland.—*Horizon :* A few hundred feet below Fell Sandstone. *Locality :* Horncliffe Dean, near Mill, south of Horncliffe village (Collection of Geological Survey, London).

Horizon : ?. *Localities :* River Tweed, 100 yards below Norham Castle (Collection of Geological Survey, Edinburgh); River Tweed, south of Horncliffe village (Collection of Geological Survey, Edinburgh); River Coquet, $\frac{1}{2}$ mile N.N.W. of Holystone (Collection of Geological Survey, London); Coomsdon Burn, $\frac{1}{2}$ mile south-west from junction with River Rede (Collection of Geological Survey, London); Hawkburn, near Catcleuch, Redesdale (Collection of Geological Survey, London); Spithope Burn, Redesdale (Collection of Geological Survey, London); Crawley Dean (east of road), $\frac{1}{3}$ mile south of Powburn, near Ingram (Collection of Geological Survey, London).

? GROUP.

Berwickshire.—*Horizon :* ?. *Localities :* Kinimerghame Quarry, near Duns (Collection of Geological Survey, Edinburgh); Cove, south of Cockburnspath (Collection of Geological Survey, Edinburgh).

Alcicornopteris Zeilleri Vaffier.

Plate CVIII, figs. 7, 7*a*, 8; text-fig. 39.

1901. *Alcicornopteris Zeilleri* Vaffier, " Étude géol. et paléont. du Carbon. Infér. du Mâconnais," *Ann. Univ. de Lyon*, Nouv. Sér. i (Sci. et Méd.), fasc. 7, p. 125, pl. vi, fig. 5; pl. vii, figs. 1, 1*a*–1*f*.

Description.—Pteridosperm. Petiole increases gradually in width from below upwards, dichotomizes at the apex at almost a straight angle, and divides the frond into two sections. The rachises of the sections undergo further dichotomy. The petiole immediately below the dichotomy is at least 4 mm. in breadth. The resulting series of rachises have little or no distinct flat wing-like margin, and are only slightly circinately coiled or twisted.

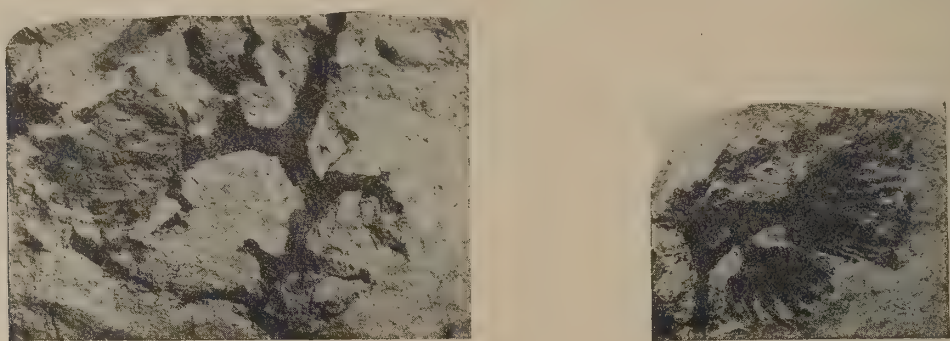
Synangia large, terminating the forks of a dichotomy, cup-shaped, 2 cm. in breadth and about 1·5 cm. in length, and bear many narrow-linear microsporangia 1 cm. in length.

Remarks.—The material on which this species is founded seems to have undergone considerable maceration before being embedded in the rock. It differs from *Alcicornopteris convoluta* in the smaller size of the rachises, their narrow flattened border without any approach to the formation of a definite wing, the absence of the large foliar expansions, and in the ramifications of the frond being less circinately bent or convoluted.

The two small specimens, provisionally referred to *Alcicornopteris Zeilleri* Vaffier, are the only examples of the plant that I have seen. They are shown natural size on Pl. CVIII, figs. 7 and 8, and fig. 7 is enlarged two times at fig. 7*a*. Their size corresponds well with that of the species to which they are here provisionally referred, but the divisions of the frond are more circinately twisted than seen on VAFFIER's specimens.

The most interesting point relating to *Alcicornopteris Zeilleri* is the fortunate discovery by M. VAFFIER of the synangia in organic connexion with the rachis of his plant. Two of his figures are given in text-fig. 39 (A and B).

Text-fig. 39 (A) shows a dichotomously divided rachis, on each branch of which a synangium is borne. These are large, being about 2 cm. in breadth and 1·50 cm. in length. M. VAFFIER regarded this specimen as showing a closed indusium from



A B

TEXT-FIG. 39.—*Alcicornopteris Zeilleri* Vaffier. A. Synangia borne at the ends of dichotomously divided divisions of the rachis. B. Two synangia showing the microsporangia. Natural size. (Copied from VAFFIER.)

which the spores had not escaped. Text-fig. 39 (B) represents what he regarded as a similar fructification which had reached a more advanced state of maturity, the indusium having split into segments. He gives another figure (pl. vii, fig. 1*c*) which is described as a split indusium, in which one can clearly distinguish its division into six valves.

Our text-fig. 39 (A) may represent an immature synangium in which the microsporangia are still adpressed to each other laterally, as in the immature synangia of *Telangium*,* but the specimen might also be explained as being possibly a cupule, though one cannot decide this from an examination of his figure. The same remarks apply to his fig. 1*c*, which is difficult to interpret. There can be little doubt, however, as to the interpretation of the synangium shown in our text-fig. 39 (B). Here there is evidently a synangium formed of numerous long, narrow microsporangia which stand upright on the disc to which they are attached, and continue in the direct line of the rachis. The general type of structure of the synangia of *Alcicornopteris* is similar to that of *Telangium*, and is seen in *Telangium affine* L. and H. sp. (Pl. CI, figs. 1 and 5;

* See BENSON, "*Telangium Scotti*," *Ann. of Bot.*, vol. xviii, p. 162, 1904.

Pl. CIV, fig. 5) and *Telangium bifidum* L. and H. sp. (Pl. CIII, figs. 3–4). That this is the interpretation of the specimen seen at text-fig. 39 (B) is, I think, confirmed by the specimen of *Alcicornopteris sp.* described below.

The synangia of *Alcicornopteris* show clearly that the genus must be included in the Pteridospermeæ.

Distribution.—Very rare. I have seen only two small specimens of the plant, that is here referred to *Alcicornopteris Zeilleri*, from the undernoted locality.

CALCIFEROUS SANDSTONE SERIES.

OIL-SHALE GROUP.

Horizon: A short distance below the Hurlet Limestone. *Locality:* Shore, about ¾ mile N.N.E. of Kinghorn, Fife.

Alcicornopteris sp.

Plate CVIII, figs. 9, 9*a*; text-fig. 40.

Remarks.—The small specimen given natural size at fig. 9, Pl. CVIII, shows the crushed remains of four synangia of *Alcicornopteris*. It is preserved on a grey iron-rusted shale, which fails to yield a satisfactory photograph. What appear to be two synangia lying side by side are lettered *a* and *b*, and the remains of possibly two other imperfect synangia are lettered *c* and *d*. Those at *a* and *b* are enlarged two times at fig. 9*a*. The synangia have a campanulate form and are about 1·40 cm. in length and 1·10 cm. in breadth. That lettered *a*, notwithstanding its crushed condition, shows very well the form of the microsporangia, which was not clearly discernible on the figures given by Vaffier.* They are lanceolate and taper gradually from the base upwards, ending in a sharp point. Their length is about 1·10 cm., and towards their base they bend inwards and are attached to the margin of the campanulate disc. They are about 4 mm. in breadth. So far as one can judge, the synangia must have contained about fifteen microsporangia.

Text-fig. 40. — *Alcicornopteris sp.* Synangium *a* of fig. 9, Pl. CVIII, enlarged.

The form and arrangement of the synangia and their mode of attachment to the disc are typically those of a Pteridosperm, to which I refer the genus *Alcicornopteris*.

The whole character and size of the synangia shown at fig. 9 agree with those of *Alcicornopteris Zeilleri* Vaffier, but as no other remains of the genus were found in the bed from which our specimen was derived, it would be unsafe to refer it definitely to Vaffier's species.

* *Alcicornopteris Zeilleri* Vaffier, " Étude géol. et paléont. du Carbon. Infér. du Mâconnais," *Ann. Univ. de Lyon*, Nouv. Sér. i (Sci. et Méd.), fasc. 7, p. 124, pl. vii, figs. 1, 1A–1D, 1901.

CALCIFEROUS SANDSTONE SERIES.

OIL-SHALE GROUP.

Horizon: ?. *Locality:* Cliff, 70–80 feet in height, with waterfall, south side of Loch Humphrey Burn, about ½ mile below the Loch, Dumbartonshire (Collection of Geological Survey, Edinburgh, No. M, 411*d*).

Genus **Schuetzia** Geinitz.

1852. Göppert, "Foss. Flora d. Uebergangs.," *Nova Acta Acad. Leop.-Carol.*, xxii, p. 214.
1863. *Schuetzia* Geinitz, *Neues Jahrb. f. Min.*, p. 525.
1864. *Schuetzia* Göppert, "Foss. Flora d. permischen Formation," *Palaeontographica*, Band xii, p. 161.
1870. *Schuetzia* Schimper, "Traité de paléont. végét.," vol. iii, p. 357.
1911. *Schuetzia* Schuster, "Ueber die Fruktifikation von *Schuetzia anomala*," *Sitzb. Math.-Nat. Kl. k.k. Akad. Wissensch.*, Band cxx, Abth. i, p. 1125.
1917. *Schuetzia* Seward, "Fossil Plants," vol. iii, p. 126.
1921. *Schuetzia* Gothan in Potonié, "Lehrb. d. Paläobot." (Zweite Auflage), pp. 144, 261.
1864. Cf. *Dictyothalamus* Göppert, "Foss. Flora d. permischen Formation," p. 164.

Description.—Synangia campanulate, pedicellate, about 1·5 cm. in length and about 1 cm. in breadth, attached to an upright striated stalk-like axis, composed of numerous curved, lanceolate microsporangia, free except at their extreme base, from 1 cm. to 1·25 cm. in length, and with a width of from 1 to 2 mm. Microspores very numerous, small, globular, with a smooth surface and a triradiate ridge.

Remarks.—Various views have been expressed as to the affinities of the genus *Schuetzia* Geinitz. Göppert believed that his *Schuetzei anomala* * belonged to *Nœggerathia*, while Geinitz referred it to the Coniferæ. Schimper held the view that *Schuetzia* belonged to a coniferous plant, which was altogether paradoxical and without any analogy, either fossil or recent.†

It has now been shown, however, that the bodies forming the campanulate structure of *Schuetzia* are microsporangia, as Schuster found that they contained spores. Scottish specimens when macerated were also found to contain very numerous microspores (see Pl. CVII, figs. 11–13).

In the second edition of Potonié's "Lehrbuch der Paläobotanik," Gothan places *Schuetzia* close to *Alcicornopteris*, without definitely expressing any opinion on its affinities. If the form and arrangement of the microsporangia in the synangia of *Alcicornopteris Zeilleri* Vaffier (see text-fig. 39) be compared with those of *Schuetzia*, their agreement seems very complete. The two fructifications differ, however, in that the synangia of *Alcicornopteris* form the terminations of dichotomous branchlets, whereas in *Schuetzia* they are attached, apparently spirally, to the side of an upright and undivided axis. The synangia of these two genera have a structure so similar that it appears to me very probable that the plants included in *Schuetzia* may be the synangia of Pteridosperms.

* "Foss. Flora d. perm. Form.," p. 161, pl. xxiii, figs. 1–6; pl. xxiv, figs. 1, 2, 3, 5B.
† Schimper, *loc. cit.*, p. 257.

Schimper * unites *Dictyothalamus* Göppert † with *Schuetzia* Geinitz, and this relationship of the two genera has been generally accepted. The specimens of *Dictyothalamus Schrollianus* Göppert do not seem to have been so well preserved as those of *Schuetzia anomala* Geinitz, and it is probable that the genus *Dictyothalamus* has been founded on imperfectly preserved examples of *Schuetzia*. In any case there does not appear to be any satisfactory ground for regarding one as the staminate and the other as the seed-bearing inflorescence of a single species.

Distribution.—The genus *Schuetzia* has been recorded from the Calciferous Sandstone Series, the Carboniferous Limestone Series, the Westphalian Series,‡ and the Permian.

Schuetzia Bennieana Kidston.

Plate CVII, figs. 7, 8 (? 9–13).

1884. *Schuetzia Bennieana* Kidston, *Proc. Roy. Phys. Soc. Edin.*, vol. viii, p. 127, pl. v, fig. 2.
1884. *Schuetzia Bennieana* Kidston, *Ann. and Mag. Nat. Hist.*, sér. 5, vol. xiii, p. 77, pl. v, fig. 2.
1917. *Schuetzia Bennieana* Seward, "Fossil Plants," vol. iii, p. 127.

Description.—Stem longitudinally striated and bearing spirally-placed synangia. Synangia campanulate, pedicellate, 1·25 to 1·50 cm. in length and 1 cm. in breadth, microsporangia free, except at the extreme base where they are united to each other, linear-lanceolate, sharp-pointed, curved, about 1·25 cm. in length and 1 mm. in breadth, attached around the slightly expanded apex of the short striated pedicel. Microspores very numerous, circular in outline, with smooth surface and triradiate ridge, of an average size of 60 μ to 70 μ.

Remarks.—The two specimens shown on Pl. CVII, figs. 7, 8, show a few synangia attached to part of an axis. That at fig. 7 exhibits a termination of the stem and bears three synangia at its apex. Other synangia have been borne on the whole length of the portion of the stem which has been preserved, and their position is indicated by the bases of the pedicels, which are still seen on the stem. The stem, as well as the short pedicels of the synangia, is longitudinally striated.

The microsporangia are so closely pressed together that it is difficult to determine the number in each synangium, but in that seen at the base of the small specimen given at fig. 8, and enlarged two times at fig. 8*a*, there seem to have been from fifteen to twenty. This synangium also shows very clearly the gradual upward thickening of the pedicel, and its expansion into the disc to which the microsporangia are attached.

* *Loc. cit.*

† "Foss. Flora d. perm. Form.," p. 164.

‡ Douvillé and Zeiller, "Terr. houil. du Sud Oronais," *Comptes rendus Acad. Sci. Paris*, vol. cxlvi, p. 734, 1908.

At figs. 9 and 10 are shown some crushed masses of microsporangia and a few individual examples, both enlarged two times. These were found by the late JAMES BENNIE when examining a rotten shale for micro-organisms from the Upper Limestone Group of the Carboniferous Limestone Series; the specimens seen at figs. 7–8 are from the Oil-Shale Group of the Calciferous Sandstone Series. That the imperfect fragments given at figs. 9–10 are those of *Schuetzia* there can be no doubt, since the form of the microsporangia and the arrangement in relation to each other are similar to those of *Schuetzia Bennieana*, but owing to their fragmentary condition one cannot be certain that they belong to that species. Some of these microsporangia were macerated and each yielded a large quantity of spores. Frequently the microspores are firmly cemented together and remain in a column, corresponding in size and form to the microsporangia from which they were derived. Two such spore masses are seen enlarged seven times at figs. 11 and 12. In other cases the microspores separated, and some of these are enlarged at fig. 13. They vary in size from 50 μ to 70 μ, but the great majority of them have an average diameter of from 60 μ to 70 μ. Their outer surface is smooth and bears a triradiate ridge, which can be distinctly seen on two of the specimens in fig. 13. Their wrinkled appearance is probably due to contraction of the microspore wall subsequent to the life of the plant.

As I stated when describing the genus *Schuetzia*, I believe that *Schuetzia Bennieana* is the microsporangial condition of a Pteridosperm, for not only the form of the sporangia, but also their union with each other at their extreme base and attachment around a common disc terminating the pedicel, are characters commonly found in the synangia of known Pteridosperms.

Schuetzia Bennieana is a more slender plant than *Schuetzia anomala* Geinitz,* which also appears to have more globular synangia.

This species was named after the late JAMES BENNIE, one of the fossil collectors of the Geological Survey of Scotland, from whom I received much kind help and assistance in the earlier days of my study of the Carboniferous Flora.

Distribution.—*Schuetzia Bennieana* is very rare, and if I am correct in provisionally referring the specimens from Bilston Burn to that species, then it occurs in both divisions of the Lower Carboniferous of Scotland.

CALCIFEROUS SANDSTONE SERIES.

OIL-SHALE GROUP.

Horizon: Wardie Shales. *Localities:* Midlothian. Water of Leith, opposite Kate's Mill and Boag's Mill, near Colinton; Railway Cutting between Kate's Mill and Boag's Mill, near Colinton (Collection of Geological Survey, Edinburgh, No. B. 1277*a*).

* GÖPPERT, "Foss. Flora perm. Formation," p. 161, pl. xxiii, figs. 1–6; pl. xxiv, figs. 1, 2, 3, 5.

CARBONIFEROUS LIMESTONE SERIES.

UPPER LIMESTONE GROUP.

Schuetzia cf. *Bennieana* Kidston.

Horizon : First coal above junction with Dryden Burn. Basal beds of "Millstone Grit." *Locality :* Bilston Burn, above junction with Dryden Burn, near Polton, Midlothian.

Genus **Zeilleria** Kidston.

1884. *Zeilleria* Kidston, *Quart. Journ. Geol. Soc.*, vol. xl, p. 590.
1888. *Zeilleria* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 57.
1910. *Zeilleria* Seward, "Fossil Plants," vol. ii, p. 407.
1911. *Zeilleria* Kidston, "Végét. houil. Hainaut Belge," *Mém. Musée roy. d'hist. nat. Belgique*, vol. iv, p. 45.
1914. *Zeilleria* Bureau, "Bassin de la Basse Loire," fasc. ii, "Flores fossiles," *Études Gîtes Min. France*, p. 275.
1919. *Zeilleria* Carpentier, "Notes paléophytologiques Carbon. du bassin de la Loire," *Revue générale de Botanique*, vol. xxxi, p. 90.
1920. *Zeilleria* Carpentier, "Notes d'excursions paléobotaniques a Chalonnes et Montjean (Maine-et-Loire)," *Bull. Soc. géol. France*, 4e sér., vol. xix, p. 270.
1921. *Zeilleria* Gothan in Potonié's "Lehrb. d. Paläobotanik" (Zweite Auflage), p. 65.
1877. *Calymmotheca* Stur (*pars*), "Culm Flora," Heft ii, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. (149) 255.
1883. *Calymmotheca* Stur (*pars*), "Zur Morph. u. System. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, p. 167.
1885. *Calymmotheca* Stur (*pars*), "Carbon-Flora der Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 236.

Description.—Pteridosperms. Fertile and sterile pinnules similar in form, or the fertile ones very slightly reduced. Microsporangia about 1 mm. in length, borne at the apex of the pinnules and pinnule-segments, sometimes on a short pedicel formed by the excurrent vein. In early condition globular or oval, in one case at least, bilocular, splitting at maturity into four or five valves or segments for the dissemination of the spores, the segments spreading out in the form of a four- or five-rayed star. Cupule of seed also split into four or five valves which likewise spread out in the form of a rayed star, larger than those of the microsporangia, and measuring 3 mm. across. Seed unknown. Foliage of the *Sphenopteris* or *Rhodea* type of pinnule segmentation.

Remarks.—A considerable diversity of opinion as to the interpretation of the structure of the microsporangia of *Zeilleria* seems to exist amongst botanists, and on that account a full list of references to the description of the genus is given above.

The curious structure of the microsporangia was difficult to explain from knowledge derived from existing cryptogams as it presents a unique type of sporangium. In its early state of development it consists of an oval or globular body borne at the ends of the pinnule-segments or at the apices of the pinnules. In *Zeilleria delicatula* the vein seems to extend a short distance beyond the margin of the pinnule segment or apex, and forms a short pedicel to the microsporangium (Pl. XCIX, fig. 2*a*). At maturity the microsporangium divides into four or five segments or valves (Pl. XCIX, fig. 2*b*), and these when open often appear as a little rayed star. NATHORST was the first to show that these structures, such as seen on Pl. XCIX, fig. 1*a*, were sporangia, and not small seeds as supposed by some; he obtained coherent masses of spores from some specimens that he macerated.*

I have recently been able to show that the microsporangia of *Zeilleria Avoldensis* are bilocular, and that each loculus contains a fusiform mass of very numerous small spores (Pl. XCVIII, figs. 3–5). When the four or five segments of the empty microsporangia are spread out in the form of a little star their appearance is similar to that of small seed-cupules.

In addition to a microsporangia-bearing specimen of *Zeilleria Avoldensis*, Mr H. W. HUGHES has also shown me an example on which seed-cupules occur. A small part of this is given on Pl. XCIX, fig. 1, enlarged two and a half times.† The cupules have a diameter of fully 3 mm., and are therefore larger than the microsporangia when spread out in the form of a little star. They show a central mammilla-like protuberance to which some organ, which I can only presume to have been a seed, has been attached. This is seen distinctly in the cupule marked *a* in fig. 1, Pl. XCIX, which is enlarged six times at fig. 1*a* of the same plate.

The seeds borne by *Zeilleria Avoldensis* were probably very small, but Mr D. TAIT, of the Geological Survey of Scotland, found small oval *Carpolithes* seeds in the Lanarkian Series of Midlothian which were only 1·5 mm. in length and rather less than 1 mm. in breadth. That these were true seeds and not sporangia has been fully proved, for when one was treated by NATHORST's maceration process it exhibited the nucellus, pollen chamber, and a few pollen grains. The small size of the empty cupules of *Zeilleria Avoldensis* therefore does not preclude the view that they originally enveloped seeds.

BUREAU (*loc. cit.*) describes the microsporangia of *Zeilleria* as being formed of four or five sporangia, but I think he has mistaken the segments into which the microsporangia divide for individual sporangia. Macerated specimens have clearly shown that such was not their structure.

If I am correct in interpreting the specimen shown on Pl. XCIX, figs. 1 and 1*a*, as bearing seed-cupules, then there can be no doubt that the genus *Zeilleria*, or if not the whole genus, certainly *Zeilleria Avoldensis*, belongs to the Pteridosperms. GOTHAN, however, has expressed another opinion in regard to the interpretation of this fossil, but I think it has been formed under a misapprehension of my remarks given in the original description of the specimen. Irrespective, however, of the question of the nature of the cupule-like structures on Mr HUGHES's specimen, the fact of *Zeilleria Avoldensis* bearing bilocular sporangia goes far to fix its position

* NATHORST, "Paläobotanische Mitteilungen," No. 4, *K. Svenska Vetenskaps. Akad. Handl.*, vol. xliii, No. 6, p. 10, 1908.

† See also KIDSTON, "Foss. Flora S. Stafford. Coalfield," iii, *Trans. Roy. Soc. Edin.*, vol. l, p. 92, pl. vii, figs. 5 and 5A, 1914.

amongst the Pteridosperms, for only in that group are such microsporangia known to occur.

Distribution.—The genus *Zeilleria* occurs in both Lower Carboniferous and Upper Carboniferous rocks. It first appears, so far as at present known, in the Oil-Shale Group of the Calciferous Sandstone Series, and extends up to the Etruria Marl Group of the Staffordian Series, but the Lower and Upper Carboniferous members of the genus are specifically distinct.

Zeilleria delicatula Sternberg sp.

Plate XCVII, figs. 4, *4a*, *4b*, 5, *5a*, 6, 7, *7a*.

1823. *Sphenopteris delicatula* Sternberg, "Essai flore monde prim.," vol. i, fasc. ii, p. 34, pl. xxvi, fig. 5; fasc. iv, p. xvi; fasc. v–vi, p. 60.
1848. *Sphenopteris delicatula* Sauveur, "Végét. foss. terr. houil. de la Belgique," pl. xxiii, fig. 5 (? xxv, fig. 2).
1910. *Sphenopteris delicatula* Deltenre in RENIER, "Documents pour l'étude paléont.," pl. lxvii.
1869. *Trichomanites delicatulus* Roehl (*non* Göppert), "Foss. Flora Steink.-Form. Westphalens," p. 68, pl. xvi, fig. 6B.
1884. *Zeilleria delicatula* Kidston, *Quart. Journ. Geol. Soc.*, vol. xl, p. 592, pl. xxv, figs. 1–13.
1888. *Zeilleria delicatula* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 57, text-fig. 37 A, B.
1891. *Zeilleria delicatula* Kidston, *Trans. Geol. Soc. Glasgow*, vol. ix, p. 33, pl. iii, fig. 34, *a–b*.
1899. *Zeilleria delicatula* Potonié, "Lehrb. d. Pflanzenpal.," p. 103, fig. 90 (iii).
1903. *Zeilleria delicatula* Arber, *Quart. Journ. Geol. Soc.*, vol. lix, p. 13, pl. ii, figs. 1–2.
1912. *Zeilleria delicatula* Vernon, *Quart. Journ. Geol. Soc.*, vol. lxviii, p. 637, pl. lviii, fig. 6.
1921. *Zeilleria delicatula* Gothan in POTONIÉ's "Lehrb. der Paläobotanik" (Zweite Auflage), p. 65, fig. 53*d*.
1833. *Sphenopteris meifolia* Sternberg, "Essai flore monde prim.," vol. ii, fasc. v–vi, p. 56, pl. xx, fig. 5.
1845. *Sphenopteris meifolia* Unger, "Synop. plant. foss.," p. 61 (Excl. *var.* *β trifida* Göppert).
1850. *Sphenopteris meifolia* Unger, "Genera et species," p. 112 (Excl. *var. trifida*).
1854. Cf. *Sphenopteris meifolia* Ettingshausen, "Steinkohlf. v. Radnitz," *Abhandl. k. k. geol. Reichsanst.*, Band ii, Abth. 3, p. 36, pl. xviii, fig. 3.
1869. *Sphenopteris* (*Cheil.*) *meifolia* Schimper, "Traité de paléont. végét.," vol. i, p. 383.
1836. *Cheilanthites meifolius* Göppert, "Syst. fil. Foss.," *Nova Acta Acad. Leop.-Carol.*, Band xvii, p. 24.

Description.—Frond at least tripinnate. Penultimate pinnæ alternate, lanceolate, spreading outwards at almost a right angle to the rachis, touching each other at their margins, rachis sub-flexuous; ultimate pinnæ alternate, broadly lanceolate, their margins touching; rachis winged, almost straight, the basal posterior ultimate pinna is placed on the rachis close to its point of union with or even in the angle formed by its junction with the penultimate rachis, and is smaller than the one immediately succeeding it. The lower ultimate pinnæ bear 2–3 pairs of pinnules, but as traced upwards gradually decrease in size, and towards the apex assume the form of pinnules. Pinnules very small, basal composed of two spreading, generally bifid, linear pointed or truncate segments with a bifid terminal lobe; middle pinnules usually formed of three undivided spreading segments, the uppermost reduced to a simple or bifid tooth. Terminal lobes simple or bifid. A median vein provides a veinlet to each tooth of the pinnule.

Segments of fertile pinnules somewhat elongated to form flat pedicel-like supports to the sporangia. Sporangia very small, globular when immature, but at maturity they split into four spreading segments for the dissemination of the spores.

Remarks.—The most perfect sterile example of this species that I have yet seen is shown natural size at fig. 4, Pl. XCVII. This specimen possibly represents a primary pinna, but its relationship to the frond as a whole cannot be determined.

The rachis of the ultimate pinnæ is distinctly winged as seen at fig. 4*b*, which is enlarged six times. This figure also shows the posterior ultimate pinna, which is much smaller than that immediately succeeding it. This is a characteristic feature of the species.

The pinnules are extremely small and delicate. Some are shown at fig. 4*a* enlarged two times, at fig. 4*b* enlarged six times, and one at fig. 5*a* three and a half times. The example given at fig. 5 is of a somewhat laxer growth than that seen at fig. 4. The lower pinnules usually bear three lobes, two lateral and one terminal, which are generally bifid, though one or both of the lateral lobes may be simple (fig. 5*a*). The lobes are linear and somewhat suddenly contracted into a sharp point. Frequently, however, the segments are more or less truncate, as seen in some cases on figs. 4*b* and 5*a*. This truncate appearance of the lobes may be due in part to the breaking off of the delicate carbonaceous apices of the segments when the stone containing the fossil is split open, but some of the segments appear to have had more obtuse apices than others. When, however, the plant is well preserved the pinnule-segments seem to be always more or less pointed, as shown on the enlarged figures.

The only fertile specimens of *Zeilleria delicatula* that have come under my notice are those in the Geological Department of the British Museum, on which the genus *Zeilleria* was founded. Some of the original figures are reproduced here. A small fragment, showing portions of three penultimate pinnæ, is given natural size at fig. 6. This specimen has suffered from decay, but among the fertile pinnules some sterile ones can be observed. The segments of the fertile pinnules become somewhat elongated and form flat little pedicels, to whose extremities are attached the diminutive globular immature sporangia. A small fragment showing sporangia which reached maturity is seen at fig. 7, natural size, and enlarged about two and a half times at fig. 7*a*. The sporangia are here split into four slightly spreading segments. Associated with these fertile pinnules are seen the remains of what were probably a few sterile ones.

With *Sphenopteris delicatula* Sternberg I unite *Sphenopteris meifolia* of the same author. This course has been followed by several botanists, and Göppert, who examined a " pretty good example " of *Sphenopteris meifolia* from Silesia, arrived at the conclusion that it was not specifically distinct from *Zeilleria* (*Sphenopteris*) *delicatula* Sternberg, but he has not figured this specimen. A study of the figure of *Sphenopteris meifolia* given by Sternberg also fails to bring out any real point of difference between the two species.

If the plant figured under the name of *Sphenopteris meifolia* by Ettingshausen * be accurately represented, then it seems to be specifically distinct from *Sphenopteris meifolia* Sternberg. His figure shows a plant with more wedge-shaped pinnules with broader, rounded lobes.

The plant figured and described under the name of *Sphenopteris delicatula* by Brongniart differs from Sternberg's species, not only in the form of the pinnules, but in the fine reticulation seen in the parenchyma of the limb.

The variety *trifidus* of *Sphenopteris meifolia* Sternberg described by Göppert † has been raised to specific rank by Stur ‡ under the name of *Sphenopteris* (*Calymmotheca*) *trifida* Göppert sp.

Distribution.—There is a single record of *Zeilleria delicatula* Sternberg sp. from the Staffordian Series, and although found in the Westphalian Series of several coalfields, it is not common anywhere.

STAFFORDIAN SERIES.

South Wales Coalfield.

BLACKBAND GROUP.

Horizon: No. 2 Rhondda Seam. *Locality:* Standard Collieries, Ynyshir, Glamorganshire (R. Weed).

WESTPHALIAN SERIES.

Cumberland Coalfield.

Horizon: Upper Division. Above Cannel Coal. *Locality:* Robin Hood Pit, Flimby (E. A. N. Arber).

Forest of Wyre Coalfield.

Horizon: ?. *Locality:* Railway Cutting, 150 yards south-east of Northwood House, ½ mile north of Bewdley, Worcestershire (Collection of Geological Survey, London).

Lancashire Coalfield.

Horizon: Forest Bed. *Locality:* Oldham Edge, Oldham (J. Nield).

Horizon: A short distance above Doe Mine. *Locality:* Dixon Fold, Stonecleuch, near Manchester (J. W. Coston).

Horizon: Ravenhead Coal. *Locality:* Ravenhead, St Helens (Liverpool Museum).

Leicestershire and South Derbyshire Coalfield.

Horizon: Nether Main Coal. *Locality:* Windmill Spinney Clay Pit, near Burton-on-Trent (R. D. Vernon).

* "Steinkf. v. Radnitz," *Abhandl. k. k. geol. Reichsanst.*, Band ii, Abth. 3, p. 36, pl. xviii, fig. 3, 1854.

† "Syst. foss. fil.," p. 241, pl. xv, figs. 3–4.

‡ "Carbon-flora d. Schatzlarer Schichten," p. 255, pl. xxxi, fig. 4, pl. xxxvi, fig. 3.

North Derbyshire and Nottingham Coalfield.

North Derbyshire.—*Horizon:* Black Shale Coal. *Localities:* Avenue No. 9 Colliery, Chesterfield (W. Hemingway); Bonds Main Colliery, Chesterfield (W. Hemingway).

Horizon: ?. *Locality:* No. 2 Pit, Claycross (L. Pegler).

Northumberland and Durham Coalfield.

Horizon: Crow Coal. *Locality:* Phœnix Brickworks, Crawcrook, Ryton, County of Durham.

South Staffordshire Coalfield.

Horizon: Blue Measures, 6 feet above Brooch Coal. *Localities:* East trial road, Jubilee Pit, Sandwell (H. W. Hughes); Hamstead Colliery, Great Barr, 2½ miles south-east of Walsall.

Warwickshire Coalfield.

Horizon: Ryder Seam. *Locality:* Haunchwood, near Nuneaton (A. R. Horwood).

Horizon: Seven-feet Seam. *Locality:* Chilvers Coton Clay Pit, Heath End, Nuneaton (R. D. Vernon).

Yorkshire Coalfield.

Horizon: Immediately below Better Bed Coal. *Locality:* Quarry, Brickworks, Seymour St., Bradford (M. A. Johnston).

Horizon: 90 yards above Shafton Coal. *Locality:* New Frickley Colliery Sinking, Frickley (W. Hemingway).

Horizon: Coal. *Localities:* Monckton Main Colliery, near Barnsley; Cooper's Colliery, Worsborough Dale, near Barnsley (W. Gelder); Frickley Colliery, Frickley (W. Gelder).

Zeilleria Avoldensis Stur sp.

Plate XCVIII, figs. 1–6 and 8; Plate XCIX, figs. 1, 2, and 8.

1878. *Phthinophyllum avoldense* Stur, *Verh. k. k. geol. Reichsanstalt*, p. 213.
1883. *Calymmotheca avoldensis* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, p. 171, fig. 37.
1885. *Calymmotheca avoldensis* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 251, pl. xxxvii, fig. 1, text-fig. 41, p. 238.
1899. *Calymmotheca avoldensis* Potonié, "Lehrb. d. Pflanzenpal.," p. 103, fig. 901.
1884. *Zeilleria Avoldensis* Kidston, *Quart. Journ. Geol. Soc.*, vol. xl, p. 591.
1887. *Zeilleria Avoldensis* Kidston, *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 148, pl. viii, figs. 8–10.
1910. *Zeilleria* (*Calymmatotheca*) *avoldensis* Carpentier, "Notes paléophytologiques," *Ann. Soc. géol. du Nord*, vol. xxxix, p. 7.

1913. *Zeilleria avoldensis* Gothan, "Oberschlesische Steinkohlenflora," Teil i, *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft lxxv, p. 125, pl. xvi, figs. 7–8.

1914. *Zeilleria Avoldensis* Kidston, "Foss. Flora South Staffordshire Coalfield," *Trans. Roy. Soc. Edin.*, vol. l, p. 92, pl. vii, figs. 5, 5*a*–*b*, 6, 6*a*, text-fig. 2.

1915. Cf. *Zeilleria avoldensis* Carpentier, "Quelques graines et fructifications," *Revue générale de botanique*, vol. xxvii, p. 330, pl. ix, figs. 1–2.

1921. *Zeilleria avoldensis* Gothan in Potonié's "Lehrb. d. Paläobot." (Zweite Auflage), p. 66, text-fig. 54*a*.

1913. Cf. *Sphenopteris* (*Calymmatotheca*) *avoldensis* Carpentier, "Contribution à l'étude du Carbonifère du Nord de la France," *Mém. Soc. géol. du Nord*, vol. ii, p. 385, *cf.* pl. viii, fig. 6.

Description.—Pteridosperm. Frond attaining a large size, quadripinnate. Primary pinnæ broadly lanceolate, margins overlapping, rachis smooth, straight, 6 mm. in breadth at base. Secondary pinnæ alternate, linear-lanceolate, touching or slightly overlapping; rachis straight, about 1 mm. in breadth at base; tertiary pinnæ alternate, oblong or linear-oblong with blunt points, free or touching laterally, rachis straight.

Pinnules alternate, attached by their whole base to the rachis. Those on the lower-placed tertiary pinnæ of the basal secondary pinnæ free or united to each other by their decurrent base and bear one or two pairs of small sharp-pointed teeth. Those on the upper-placed tertiary pinnæ united to each other for one-third to two-thirds of the length, with the free portion of the limb triangular in form. In the uppermost pinnæ the pinnules become so much united that the tertiary pinnæ assume the form of oblong pinnules with undulating margins. A single vein enters each pinnule and gives off a few undivided lateral veinlets. The fertile pinnules differ little in form from the sterile ones.

Fructification apparently confined to the tertiary pinnæ of the lower secondary pinnæ.

Microsporangia bilocular, 1 mm. to 1·50 mm. in length; when immature they are more or less oval and are borne at the extremities of the slightly excurrent median vein and lateral veinlets, which extend a short distance beyond the margin of the pinnule and thus form a little pedicel to the sporangia. At maturity the sporangia split into four, rarely five, spreading segments for the dissemination of the spores. Spores very numerous, circular in outline, small, from 20 μ to 28 μ in diameter, but those measured were not completely developed.

Seed surrounded by a cupule. Cupules formed of four or five segments which when spread out have a diameter of 3 mm. In their centre is a small mammilla-like protuberance to which the seed has been attached. Seed unknown.

Remarks.—Three specimens showing the sporangia are given natural size at figs. 1 and 2, Pl. XCVIII, and at fig. 2, Pl. XCIX. That at fig. 1 exhibits portion of a primary pinna, the lower secondary pinnæ of which are fertile, while the upper remain sterile. On a secondary pinna immediately below the lowest seen in the figure and that at the base of the figure on the right-hand side, the small pinnules on the tertiary pinnæ are free or are only united by their decurrent bases. As traced upwards from the base of the specimen, the pinnules become gradually more and more united to each other till the tertiary pinnæ assume the form of oblong pinnules with crenulate margins, and at the extreme apex the secondary pinnæ have also assumed a similar form. On this fertile example comparatively few sporangia are present, though at various parts they can be seen. Their arrangement on the pinnules is exhibited better at fig. 2, Pl. XCIX, of which two pinnules enlarged three and a half times are given at figs. 2*a* and 2*b*. The sporangia are attached to the ends of the excurrent midvein or lateral veinlets, which form the short pedicel to the sporangia. Fig. 2*a* shows an unopened sporangium, while fig. 2*b* shows three open sporangia. They have apparently dehisced by the sporangium splitting into four valve-like segments. On the small specimen given at fig. 2, Pl. XCVIII, natural size, and enlarged two times at fig. 2*a* to show more clearly the structural details of the specimen, the sporangia are immature, as shown by the condition of the spores, and measure only 0·50 mm. to 0·75 mm. in diameter. A macerated sporangium from this specimen is enlarged seventy-five times at fig. 3, Pl. XCVIII. This shows clearly that the sporangial masses are developed in two loculi placed close to each other and, in its present condition, are now embedded in an amber-coloured structureless substance which probably represents the not inconsiderable amount of tissue in which the loculi were enclosed. On the removal of the amber-like surrounding matter, each sporangium yielded two separate fusiform masses of coherent spores. Fig. 4, also enlarged seventy-five times, shows the two spore-masses, *a* and *b*, adhering to each other, most probably through mechanical pressure, as they are seen to be separated from each other at fig. 3, except at the base, where they appear almost if not actually to touch each other. The letters *a* and *b*, fig. 4, Pl. XCVIII, show the two basal extremities of the spore-masses. At fig. 5 a single spore-mass is given. It is of fusiform shape, slightly curved, with a rounded base, and terminates in a sharp point. A few of the microspores, enlarged 250 times, are seen at fig. 6, Pl. XCVIII. They are not fully developed, but are circular, and in their present immature condition have a diameter of from 20 μ to 28 μ.

A small part of the seed-bearing portion of a frond (contained in an ironstone nodule) is enlarged two and a half times at fig. 1*a*, Pl. XCIX. The tissue of the pinnules is seen at the upper end of the figure, but is not so well preserved as the cupules, which have been formed of a more dense and firm tissue. They are composed of four or five segments, which in this case are spread open and from all of which the seeds have fallen. That marked at *a* shows a small but distinct central mammillate protuberance to which the seed has evidently been attached. These cupules when open have a diameter of 3 mm., and are therefore much larger than the microsporangia, and so far as one can observe have been sessile on the pinnules. That the structures described as cupules are not sporangia, seems to be unquestionable, and the presence of the small round point-like elevation at their centre, as seen at fig. 1*a*, which is enlarged six times, indicates distinctly the position of attachment of an organ which I do not consider could have been anything but a seed.

From the note Gothan has appended to the description of the genus *Zeilleria* in the second edition of Potonié's "Lehrbuch der Paläobotanik," p. 65, I think he must have misunderstood the description of the cupules given in my paper on the "Fossil Flora of the South Staffordshire Coalfield" (*loc. cit.*). The preservation of the cupule-bearing specimen was not suitable for the preparation of macerated preparations, and in any case they had reached maturity and shed their contents. The structure of the cupules as seen on the specimen is sufficient, however, to show their true nature. The bilocular sporangia also point to Pteridosperm affinities, since they have only been found in organic connexion with that group of plants.

A small fragment of a sterile primary pinna is given natural size at fig. 8, Pl. XCIX. It is apparently from the upper portion of a primary pinna, since the pinnules are all united to each other almost throughout their entire length, and the tertiary pinnæ have here almost assumed the form of oblong pinnules with crenate margins, but each of the little crenatures represents the apex of one of the component pinnules.

The fertile specimen described and figured by the Abbé Carpentier,* which he compares with the fructification of *Telangium*, and on which the sporangia are said to be placed in groups of four or five on a reduced pinnule, cannot, if correctly interpreted, belong to the genus *Zeilleria*.

The form of the ultimate pinnæ and pinnules is so characteristic that *Zeilleria Avoldensis* is easily distinguished from the other members of the genus.

My thanks are due to Mr W. B. R. King, of the Sedgwick Museum, Cambridge, for permission to figure and describe the specimen given on Pl. XCVIII, fig. 2.

Distribution.—Zeilleria Avoldensis has been recorded from the Staffordian Series, where, however, it is extremely rare. In the Westphalian Series it is more frequent, but it is not a common species in that horizon.

STAFFORDIAN SERIES.

South Staffordshire Coalfield.

ETRURIA MARL GROUP.

Horizon: Old Hill Marls. Within the upper 300 feet of the Group. *Locality:* Granville Clay Pit, Old Hill Station (Rev. H. Kay).

Horizon: "Espley Band." *Locality:* Hamstead Colliery, Great Barr, 2½ miles south-east of Walsall (Sedgwick Museum, Cambridge, No. 3390).

WESTPHALIAN SERIES.

Forest of Wyre Coalfield.

Horizon: Brooch Coal. *Locality:* Kinlet Colliery, 1 mile south-west of Highley, Shropshire (Collection of Geological Survey, London).

* Carpentier, *op. cit.*

North Derbyshire and Nottingham Coalfield.

Horizon: Above Top Hard Coal. *Locality:* Shipley Clay Pit, Ilkeston, North Derbyshire (L. Moysey).

Horizon: Below Top Hard Coal. *Locality:* Loscoe Clay Pit, Heanor, North Derbyshire (L. Moysey).

Northumberland and Durham Coalfield.

Horizon: Crow Coal. *Locality:* Phœnix Brickworks, Crawcrook, Ryton, County of Durham (W. Eltringham).

South Staffordshire Coalfield.

Horizon: Blue Measures, 6 feet above Brooch Coal. *Locality:* Hamstead Colliery, Great Barr, 2½ miles south-east of Walsall (H. Insley).

Horizon: Roof of Brooch Coal. *Localities:* Tividale; Shut End.

Horizon: Ten-foot Ironstone Measures. *Locality:* Clayscroft openwork, Coseley, near Dudley.

Horizon: New Mine Coal. *Locality:* Clattershaw Colliery, Brettell Lane, 1½ miles north-east of Stourbridge (H. W. Hughes).

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Locality:* Roundgreen Colliery, near Barnsley (W. Hemingway).

South Wales Coalfield.

Horizon: Five-foot Seam (= Seven-foot Seam of Clydach Vale). *Locality:* Britannic Collieries, Gilfach Goch, Glamorganshire (D. Davies).

Horizon: Six-foot Seam. *Locality:* Trane Colliery, Gilfach Goch, Glamorganshire (D. Davies).

Horizon: Upper Yard Seam (=Bute Seam). *Locality:* Britannic Collieries, Gilfach Goch, Glamorganshire (D. Davies).

Zeilleria Frenzli Stur sp.

Plate XCVII, figs. 3, 3*a*, and 3*b*.

1883. *Calymmotheca Frenzli* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzungsb. k. Akad. Wiss. Wien*, Band lxxxviii, Abth. 1, p. 172, fig. 38.

1885. *Calymmotheca Frenzli* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 268, pl. xxxvii, figs. 2–3; pl. xxxviii, fig. 3, text-fig. 42, p. 239.

1899. *Calymmotheca Frenzli* Potonié, "Lehrb. d. Pflanzenpal.," p. 103, fig. 90.

1884. *Zeilleria Frenzli* Kidston, *Quart. Journ. Geol. Soc.*, vol. xl, p. 591.
1899. *Sphenopteris* (*Zeilleria*) *Frenzli* Zeiller, " Flore foss. bassin houil. d'Héraclée," *Mém. Soc. géol. France, Paléont.*, No. 21, p. 12, pl. i, fig. 17.
1913. *Zeilleria Frenzli* Gothan, " Oberschlesische Steinkohlenflora," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft lxxv, p. 121, pl. viii, figs. 3, 3*a*, 3*b* ; pl. xxviii, figs. 4, 4*a*.

Description.—Frond large, at least tripinnate. Rachis bearing penultimate pinnæ, straight or very slightly flexuous, smooth. Penultimate pinnæ alternate, deltoid ; ultimate pinnæ alternate, oblong, attaining a length of 1 cm., rachis straight, flat. Pinnules alternate, with a roughened surface ; the basal divided into three or four linear pointed lobes ; upper pinnules smaller with fewer lobes, while those near the apex are bifid or reduced to a single linear segment. Nervation imperfectly shown, but a single vein seems to enter each segment of the pinnule.

The fertile pinnules, which are similar to the sterile ones, bear the microsporangia at the extremity of the lobes. In the early condition of development the microsporangia are globular, but at maturity they split into three or four segments for the dissemination of the spores.

Remarks.—Portion of a fertile frond of *Zeilleria Frenzli*, the only British example that I have seen, is given natural size on Pl. XCVII, fig. 3. It shows the upper part of what is probably a primary pinna. If this be its true description, then the frond was quadripinnate.

The penultimate pinnæ are deltoid, but on the specimen figured by Gothan, which probably represents a lower portion of a pinna (or frond) they are more oblong and bear nine pairs of ultimate pinnæ. The rachis is broad and flat. The ultimate pinnæ are oblong and have a flat rachis, but its apparent flatness may be due to its being winged. The larger ultimate pinnæ bear four or five pairs of alternate pinnules, of which the basal have two or three linear lateral segments which suddenly contract into a short sharp point.

The enlargement given by Stur in his text-fig. 42 * is, according to Gothan,† who has examined the original specimens, inaccurate, as neither sterile pinnules nor those bearing the microsporangia show the segments to end in the long, narrow, sharp points depicted by him. The roughened surface of the pinnules seems to be caused by papillose development of the epidermal cells.

The microsporangia-bearing segments of the fertile pinnules only differ from the sterile ones in their apex bearing a sporangium instead of ending in a short sharp point (fig. 3*b*).

A fertile penultimate pinna is enlarged one and three-quarter times at fig. 3*a*. This shows the lax growth-characters of the species. The flat rachis from which the pinnules spring is of about the same width as that of the pinnule-segments, but, as already mentioned, the flatness of the rachis is probably due to its being winged. Sterile pinnules appear to occur in association with the fertile ones.

All the specimens described by Stur were fertile, but sterile examples have

* *Loc. cit.* † *Loc. cit.*, p. 122.

been figured and described by ZEILLER and GOTHAN,* which show the lax spreading character of the sterile pinnæ and pinnules.

In the general type of growth of *Zeilleria Frenzli* Stur sp. the segmentation of the sterile pinnules and their roughened surface is very similar to that of *Crossotheca Schatzlarensis* Stur,† but in the latter the pinnules are more delicate and have slightly narrower segments, and the pinnæ seem to be always placed more obliquely to the rachis. The fructification of the two plants is essentially different, however, but when examples of the two species are compared, even in the barren condition, they show a very distinctive appearance, which is difficult to describe verbally.

Zeilleria Frenzli is also closely related to *Zeilleria Schaumburg-Lippeana* Stur sp., ‡ but if I am correct in what I believe to be the form of the pinnules in this latter species they have a much broader limb, and the segments terminate in an obtusely rounded apex.§ GOTHAN, however, appears to hold a somewhat different view as to the form of the pinnules in *Zeilleria Schaumburg-Lippeana.*|| In any case, we are both of the opinion that *Zeilleria Frenzli* and *Zeilleria Schaumburg-Lippeana* are specifically distinct.

Through the kindness of the Abbé CARPENTIER I have examined the specimens that he and M. DEPAPE figured and described under the name of *Zeilleria Frenzli,*¶ but I believe they are specifically distinct from that species. In 1915 they again figure some sporangia of their *Zeilleria Frenzli* and say: " Le pédicelle qui porte les fructifications est un lobe ou lobule atténué à son extrémité, lobe ou lobule d'une foliole à limbe réduit mais conservé. A l'extrémité de ce lobe transformé en pédicelle les microsporanges sont groupés par 4 (peut-être par 5) dans le *Zeilleria Frenzli* Stur sp., par 4 ou 6 dans le *Zeilleria avoldensis* Stur sp. La nervure médiane du pédicelle se termine au centre de ce groupe de microsporanges." **

If this description be correct, then their fructification cannot be placed in the genus *Zeilleria.* On the other hand, it is possible their microsporangia may have reached maturity, and the appearance of the fructification as being formed of four or five sporangia may have been caused by the walls of the microsporangia having begun to separate, preparatory to opening for the dissemination of the spores. Their fig. 4 conveys this impression rather than that of a group of free sporangia.

Distribution.—The only British specimen I have seen is that figured on Pl. XCVII, fig. 3, which was collected by the late G. H. KNOTT. The species has been found only in the Westphalian Series.

* *Loc. cit.*

† See *ante*, p. 340.

‡ *Calymmotheca Schaumburg-Lippeana* Stur, " Carbon-Flora d. Schatzlarer Schichten," p. 272, pl. xxxvi, figs. 5–6, 1885.

§ See KIDSTON, " Végét. houil. Hainaut Belge," *Mém. Mus. roy. Hist. Nat. Belge,* vol. iv, p. 45, pl. iii, figs. 1, 2, 2A, 1911.

|| See GOTHAN, *loc. cit.*, p. 123.

¶ CARPENTIER and DEPAPE, " Sur quelques *Sphenopteris* fertiles du Westphalien," *Ann. Soc. géol. du Nord,* vol. xliii, p. 307, pl. iv, figs. 1–5; pl. v, fig. 1, 1914.

** G. DEPAPE and A. CARPENTIER, " Sur quelques graines et fructifications du Westphalien du Nord de la France," *Revue générale de botan.*, vol. xxvii, p. 330, pl. ix, figs. 3–5, 1915.

WESTPHALIAN SERIES.

Yorkshire Coalfield.

Horizon: Cannel Coal. *Locality:* Stanley Colliery, Liversedge, 6½ miles south-east of Bradford.

Zeilleria hymenophylloides Kidston n. sp.

Plate XCVII, figs. 1, 1*a*, 2, 2*a*; Plate XCIX, figs. 9, 10, 10*a*, 11.

Description.—Frond at least tripinnate, but probably quadripinnate. Rachis smooth, straight, 5 mm. or more in breadth. Penultimate pinnæ lanceolate, alternate; rachis straight or very slightly flexuous, winged, smooth or with delicate longitudinal striations; ultimate pinnæ lanceolate, alternate, free or slightly overlapping; rachis straight, winged. Sterile pinnules alternate, composed of very delicate tissue, ovate, decurrent, contracted at base, attached to the rachis by a wide footstalk and divided into 2–6 simple, more rarely bifid, obtuse or obtusely pointed lobes. Median vein sub-geniculate, from which simple or bifid veinlets are given off, one branch extending to the apex of each lobe or tooth; terminal lobe generally bifid. Fertile pinnules with slightly narrower and longer segments, the terminal and upper lateral of which bear a single oval sporangium.

Remarks.—The limb of the pinnules of *Zeilleria hymenophylloides* has been composed of very delicate tissue and is sometimes not well preserved, but, in addition, the majority of the specimens have been found in ironstone or ironstone nodules, and even when well preserved the fracture of the stone frequently passes through the upturned segments of the pinnules and cuts them off. Hence perfect pinnules are not frequently obtained. On all my specimens the plant is represented by a darker brown colour on a chocolate-coloured matrix, which makes it difficult to reproduce them by photography.

My first specimens were received from Mr J. W. Bond, of Leeds, in 1899, and one of these is given at fig. 9, Pl. XCIX, natural size.

It is impossible to determine whether this specimen represents the upper portion of a frond or of a primary pinna; if the latter, the frond has been quadripinnate. For the most part the pinnules have been damaged by the fracture of the stone cutting off the apices of the segments. The specimen gives, however, a fair idea of the growth-character of the species.

The complete form of the pinnules is best seen on the small specimen given on Pl. XCVII, fig. 1, of which a part is enlarged two times at fig. 11, Pl. XCIX. The decurrent pinnules are placed obliquely on the winged rachis, and two of them are enlarged six times at fig. 1*a*, Pl. XCVII, to show more clearly their form.

Each bears a few lobes, with almost straight sides which contract somewhat suddenly into an obtuse or blunt point and are separated by a sharp-pointed sinus. In these two pinnules all the lobes are simple, but in the larger pinnules on pinnæ holding a lower position on the frond the lower lobes are frequently bifid.

The midrib, which is almost straight or slightly flexuous, gives off simple veinlets, one of which extends to the apex of each tooth.

At fig. 10, Pl. XCIX, is given a portion of a specimen which I think shows part of the main rachis of the frond and some fragments of the primary pinnæ. The rachis is smooth, 5 mm. in breadth, and has a central band which may represent the vascular strand. The rachises of the pinnæ which spring from it are 1·5 cm. in breadth at their base. Part of one of the pinnæ of this example is given enlarged two times at fig. 10*a*. The apices of the segments of the pinnules are mostly broken over, but the figure gives a fair idea of the general character of the species.

A small fertile specimen is seen at fig. 2, Pl. XCVII. The fertile pinnules have slightly narrower and proportionally longer segments. The oval sporangia are attached to the truncate extremities of the pinnule segments as seen at fig. 2*a*, which is enlarged nine times. They vary in size from about 0·75 to 1 mm. in length. The sporangia do not appear to have been very plentifully produced, and seem to have been restricted to the upper pinnules of the ultimate pinnæ as they only occur in this position on all the fertile examples I have examined. At maturity they split into four valves.*

Zeilleria hymenophylloides has a slight resemblance to *Hymenophyllum antiquum* Bureau,† but in that species the pinnules are smaller, oblong, and narrower; they have simple segments, and the sporangia are borne *on* the apices of the pinnules and are surrounded on three sides by the limb of the segment. The species is also smaller in all its parts.

From *Sphenopteris Kayi* Arber ‡ *Zeilleria hymenophylloides* is also easily distinguished by its shorter, broader, and more spreading segments. A comparison of Pl. XCVII, fig. 1*a*, with Pl. XXI, fig. 3*b*, will at once show these differences.

Distribution.—Very rare, and only known from the Westphalian Series.

WESTPHALIAN SERIES.

Burnley Coalfield.

Horizon: Outcrop of Arley Mine. *Locality:* Brickwork, Hibson Road at Marsden Height, Nelson, Lancashire (P. Whalley).

South Staffordshire Coalfield.

Horizon: Blue Measures, above Brooch Coal. *Locality:* Trial Road, Jubilee Pit, Sandwell (H. W. Hughes).

Yorkshire Coalfield.

Horizon: Shale immediately below Better Bed Coal. *Locality:* Quarry, Brickwork, Seymour St., Bradford (M. A. Johnston).

Horizon: Below Black Bed Coal. *Locality:* Dolly Lane, Leeds (J. W. Bond).

* Shown on specimen K/3657.

† Ed. Bureau, "Bassin de la Basse Loire," (*Études Gîtes Min. France*), fasc. ii, "Flores fossiles," p. 78, pl. xiii, figs. 4, 4a, 4b; pl. xx, figs. 1, 1a, 1b, 2a, 2b, 1914.

‡ See *ante*, p. 98.

Zeilleria Moravica Ettingshausen sp.

Plate LXII, figs. 3–5 ; Plate CXIII, fig. 4.

1865. *Trichomanes moravicum* Ettingshausen, "Foss. Flora d. Mähr.-Schles. Dachschiefers," *Denkschr. Math.-Nat. Kl. k. Akad. Wissensch.*, Band xxv, p. 77 (24), fig. 9, pl. vi, fig. 4.
1869. *Sphenopteris* (*Trichom.*) *moravica* Schimper, "Traité de paléont. végét.," vol. i, p. 414.
1883. *Sphenopteris moravica* Renault, "Cours de botan. foss.," vol. iii, p. 193.
1875. *Rhodea moravica* Stur, "Culm Flora," *Abhandl. k. k. geol. Reichsanst.*, Band viii, Heft 1, p. 38, pl. x, figs. 3–7 ; pl. xi, fig. 1.
1891. *Rhodea moravica* Vaffier, "Étude géol. et paléont. du Carbon. inférieur du Mâconnais," *Ann. Univ. Lyon*, Nouv. Sér. i (Sci. et Méd.), fasc. 7, p. 109, pl. iii, figs. 2, 2*a*, 2*b*, 2*c*, 2*d*.
1903. *Rhodea Moravica* Kidston, "Foss. Plants Canonbie, etc.," *Trans. Roy. Soc. Edin.*, vol. xl, p. 817, text-fig. 2, p. 812, pl. v, figs. 48–49.
1877. *Calymmotheca moravica* Stur, "Culm Flora," Heft 2 (*loc. cit.*), p. 278.
1883. *Calymmotheca moravica* Stur, "Morph. u. System. d. Culm-u. Carbonfarne," *Sitz. k. Akad. Wissensch.*, Abth. 1, p. 174.
1914. *Zeilleria moravica* E. Bureau, "Bassin de la Basse Loire," fasc. 2 (*Études Gîtes Min. France*), "Flores fossiles," p. 276, pl. xviii, figs. 1–4.
1918. *Zeilleria moravica* Carpentier, "Excursions bassin houil. Basse Loire," *Bull. Soc. géol. France*, 4e sér., vol. xviii, p. 243, pl. iv, fig. 10.
1919. *Zeilleria moravica* Carpentier, "Notes paléophytologiques sur le Carbon du bassin de la Basse Loire," *Revue générale de Botan.*, vol. xxxi, p. 90, pl. iii, figs. 9, 10.
1920. *Zeilleria moravica* Carpentier, "Notes d'excursions paléobotaniques à Chalonnes et Montjean (Maine et Loire)," *Bull. Soc. géol. France*, 4e sér., vol. xix, p. 270, pl. viii, figs. 10–12.

Description.—Frond large, at least tripinnate, rachis straight, longitudinally striated and attaining a width of 6 mm. or more. Penultimate pinnæ lanceolate or narrow-deltoid, with straight or slightly flexuous smooth or faintly striated rachis, 2 mm. or more in breadth at base and showing a thread-like band passing up the middle. Ultimate pinnæ alternate, slightly oblique, of an oblong or oblong-deltoid form, the upper ones of a sub-rhomboidal contour. As traced upwards, the ultimate pinnæ assume the form of pinnules. Pinnules alternate, attaining a length of 1 cm., but usually about half that size. The larger usually bear four ultimate linear segments which result from two dichotomies, but occasionally they contain a greater number of segments through a further dichotomous division of one or more of them. The pinnules holding a higher position on the rachis have generally three or only two segments, while the terminal ones may be reduced to a single segment. Segments narrow-linear, contracting at apex into a point. A single vein passes into each segment or tooth of the pinnule.

Remarks.—Though *Zeilleria Moravica* Ettingshausen sp. has a wide geographical distribution, it almost invariably occurs in an imperfect state of preservation, and all the British specimens I have seen are unfortunately in that condition.

A specimen showing what I regard as a part of the upper portion of a frond, though it might be that of a primary pinna, is given natural size on Pl. CXIII, fig. 4. The broad central rachis gives off alternate pinnæ with flat rachises which in turn bear the ultimate pinnæ, the upper of which are reduced to the form of pinnules. A median furrow runs up the middle of the rachis and probably indicates the position of the vascular strand. In other cases a thread-like strand occupies the position of the furrow. These two different appearances probably depend on whether the upper or lower surface of the rachis is exposed to view. The breadth of the rachis appears to be caused by the presence of a wing, but there is no clear distinction on our specimen between the rachis and what may be a marginal wing. Corresponding to the reduced size of the ultimate pinnæ, the pinnules are smaller and seldom consist of more than a dichotomous fork, while the upper ultimate pinnæ assume the form of the pinnules borne by the ultimate pinnæ on lower regions of the frond. None of the pinnæ on this example show the apical portion.

Two small fragments of *Zeilleria Moravica* are given natural size on Pl. LXII, figs. 3–4. Both of these small fragments show probably upper portions of primary pinnæ, with the secondary or ultimate pinnæ much reduced and assuming the form of pinnules. One of these ultimate pinnæ is enlarged at fig. 5, to show the form of the segments. The segments contract somewhat suddenly, and when well preserved end in an obtuse, but distinctly pointed apex.

M. E. Bureau and the Abbé Carpentier * describe fertile specimens of *Rhodea Moravica* which they refer to the genus *Zeilleria.* Bureau describes the fertile pinnules as terminating in four capsules united at their base and at maturity spreading out like a star. The Abbé Carpentier describes his fertile examples as small carbonaceous capsules, 1 mm. in length, formed of four sharp lobes, simulating open cupules and terminating the ultimate divisions of a frond. He questions whether they are cupules or groups of microsporangia, and suggests that one sees an ovoid central organ in a small opened cupule.†

Bureau,‡ in discussing the genus *Zeilleria* Kidston, describes the fructifications as at the extremity of the lobes of certain pinnules in capsules (anthers) grouped in four and opening from the summit to the base. From this description there seems to be little doubt that Bureau regarded the valves or segments of the microsporangia of *Rhodea Moravica* as individual *microsporangia,* for he still regards *Zeilleria delicatula* as the type of the genus, § where the fructifications are certainly microsporangia that split into segments at maturity for the dissemination of the spores. I therefore think that he has probably misinterpreted the fertile organs on his specimens, and retain *Rhodea Moravica* in the genus *Zeilleria.* There may, however, be another explanation of the fertile organs described by Bureau and figured on his pl. xviii, fig. 1. So far as one can see from this figure, the fertile structures are 3 mm. in diameter when spread out as a star. This is larger than any microsporangia of *Zeilleria* that I have seen, but is the same size as the empty cupules of *Zeilleria Avoldensis.* It is therefore possible that his specimen shows the cupules from which seeds have fallen. The fact that they are open and the segments spread out like a star seems distinctly to indicate that they had reached maturity. The same investigator describes and

* *Loc. cit.*

† Carpentier, *Bull. Soc. géol. France,* 4e sér., vol. xviii, p. 243, 1918.

‡ " Bassin de la Basse Loire," fasc. ii, " Flores fossiles," p. 275.

§ *Loc. cit.,* p. 277.

figures (pl. xviii, fig. 1 at left-hand margin) what he terms a petiole of *Zeilleria Moravica* 4 cm. in breadth, with peculiar irregular longitudinal rows, 3 to 4 mm. apart, formed of furrows of varying length. It does not appear, however, that this "petiole" showed any pinnæ of that species in organic connexion with it, and its association on the slab with fragments of *Zeilleria Moravica* may be the result of mere accident.

Zeilleria Moravica Ettingshausen sp. has a considerable resemblance to *Rhodea Smithi* Kidston, figured on Pl. LVI, figs. 1, 2, and Pl. LVII, figs. 2, 3, but the pinnules in the latter species are larger and have longer segments, the ultimate pinnæ are more broadly deltoid and the rachis has the characteristic Heterangium type of cortical structure, while in *Zeilleria Moravica* the cortex is smooth or only shows faint longitudinal striations.

Distribution.—Zeilleria Moravica Ettingshausen sp. is restricted to Lower Carboniferous rocks and occurs in both the Carboniferous Limestone Series and Calciferous Sandstone Series, but in the latter it appears to be restricted to the Oil-Shale Group. Though noted from a number of localities, it is not common at any of them.

CARBONIFEROUS LIMESTONE SERIES.

UPPER LIMESTONE GROUP.

Fifeshire.—*Horizon:* ?. *Locality:* Midstrathore Boring, Thornton.

Horizon: Shale below sandstone on which Ardross Castle is built. *Locality:* Ardross.

Lanarkshire.—*Horizon:* 70–80 feet above Castlecary Limestone. *Locality:* Quarry, Garngad Road, Glasgow (Collection of Geological Survey, Edinburgh).

Horizon: About 35 feet below Orchard Limestone. *Locality:* Pit Boring, Robroyston Colliery, $1\frac{3}{4}$ miles south-east of Bishopbriggs.

Renfrewshire.—*Horizon:* Immediately below Orchard Limestone. *Locality:* New Braidbar Quarry, Giffnock (P. Macnair).

Stirlingshire.—*Horizon:* 13 fathoms above Calmy Limestone. *Locality:* Rose-hill Diamond Boring, Plean (Collection of Geological Survey, Edinburgh).

LIMESTONE COAL GROUP.

Dumbartonshire.—(Detached.) *Horizon:* At depth of 212 fathoms 4 feet from surface. *Locality:* Thorneycroft's No. 1 Boring, $\frac{1}{4}$ mile north-east of Cumbernauld Railway Station (Collection of Geological Survey, Edinburgh).

(?) UPPER LIMESTONE GROUP.

Yorkshire.—*Horizon:* "Yoredale Group." *Locality:* Thirstfield, near Grassington, Wharfedale (W. Hind).

CALCIFEROUS SANDSTONE SERIES.

OIL-SHALE GROUP.

Island of Arran.—*Horizon :* ?. *Locality :* Shore, 750 yards south-east of Laggan Cottage, 5 miles north of Corrie (Collection of Geological Survey, Edinburgh).

Berwickshire.—*Horizon :* In shale and ironstone band in shale on horizon of Scremerston Coal strata. *Locality :* 90 yards south of entrance to Cove Harbour, Cockburnspath (Collection of Geological Survey, Edinburgh).

Fifeshire.—*Horizon :* Shale above Burdiehouse Limestone. *Localities :* Kilmundy Quarry, 1 mile north-west of Burntisland ; Grange Quarry, Burntisland.

Horizon : A short distance above the Hurlet Limestone. *Locality :* Shore, about ¾ mile N.N.E. of Kinghorn, almost immediately below the Combination Poor House.

Horizon : ?. *Locality :* Shore, Blind Caput, Pittenweem.

Haddingtonshire.—*Horizon :* Shale in sandstone overlying Linkhead Limestone. *Locality :* A quarter of a mile south-east of Linkhead, near Innerwick (Collection of Geological Survey, Edinburgh).

Horizon : Bituminous shale resting on Linkhead Coal. *Locality :* Bay west of Standalane, about ½ mile south-east of Linkhead, near Innerwick (Collection of Geological Survey, Edinburgh).

Lanarkshire.—*Horizon :* 21 fathoms below Hurlet Limestone. *Locality :* Rotten Calder, Calderwood Glen, between East Kilbride and Blantyre (Collection of Geological Survey, Edinburgh).

Horizon : About 17 fathoms below Hurlet Limestone. *Locality :* Cot Castle Farm, Avon Water, about ⅛ mile north of Strathaven (Collection of Geological Survey, Edinburgh).

Renfrewshire.—*Horizon :* About 100 fathoms below the Hurlet Limestone. *Locality :* Railway cutting near Tillysow, about 1½ miles south-east of Paisley (Collection of Geological Survey, Edinburgh).

Northumberland.—*Horizon :* Top of Calciferous Sandstone Series. *Locality :* Shore section, west of Budle, Chesterfield Slakes.

Genus **Telangium** Benson.

1904. *Telangium* Benson, *Ann. of Bot.*, vol. xviii, p. 162.
1906. *Telangium* Kidston, "Microsporangia of the Pteridosperms," *Phil. Trans.*, Ser. B, vol. cxcviii, p. 430.
1913. *Telangium* Carpentier, "Contribution à l'étude du Carbon du Nord de la France," *Mém. Soc. géol. du Nord*, vol. vii, p. 377.
1914. *Telangium* Nathorst, "Foss. Flora d. Polarländer," Teil 1, Lief. 4, "Nachtrag zur Paläoz. Flora Spitzbergens," p. 20.
1915. *Telangium* Carpentier, "Graines et fructifications du Westphalien du Nord de la France," *Revue générale de botanique*, vol. xxvii, p. 330.
1917. *Telangium* Seward, "Fossil Plants," vol. iii, p. 54.

1920. *Telangium* Carpentier, "Notes d'excursions paléobotanique a Chalonnes et Montjean (Maine-et-Loire)," *Bull. Soc. géol. France*, 4e sér., vol. xix, p. 269.

1920. *Telangium* Carpentier, "Contribution a l'étude des fructifications du Culm de Mouzeil (Loire Inférieure)," *Revue générale de botanique*, vol. xxxii, p. 345.

1921. *Telangium* Gothan in POTONIÉ's "Lehrb. d. Paläobot." (Zweite Auflage), p. 133.

1923. *Telangium* Scott, "Studies in Fossil Botany," 3rd ed., pt. 2, p. 78.

1891. *Calymmatotheca* Kidston (*non* Stur), *Trans. Geol. Soc. Glasgow*, vol. ix, p. 23.

Description.—Pteridosperms. Fertile and barren pinnæ dissimilar. Fertile pinnæ bear synangia only, synangia borne at the extremity of the ultimate ramifications of the rachis, composed of 6–25 fusiform microsporangia which taper to the apex and are attached to a disc-like body which terminates the ultimate divisions of the rachis. Microsporangia unilocular. Only the cupule of the seeds is known (*Telangium bifidum* L. and H. sp.).

Remarks.—In the description of the genus given above only those characters which have been observed on specimens preserved as incrustations are mentioned,* but as some generic relationships require to be discussed, I add here Dr BENSON's original description of the genus *Telangium.* There is, however, little reason to doubt that the other characters given in the original generic description were also possessed by the incrustations as well as by the specimens preserved as petrifactions. "Fertile and barren pinnæ dissimilar; fertile pinnæ represented by synangia only; synangia borne at the extremity of the ultimate ramifications of rachis, composed of 6–12 sporangia which taper to the apex and are united primarily for almost their whole length to form a body which is continued into a sterile base of decreasing diameter through which runs longitudinally a single vascular strand. Each sporange ultimately becomes almost free from the others by septicidal dehiscence and liberates large spores from a ventral suture." †

There is an entire absence of the limb on the fertile pinnæ, and the microsporangia are attached to a disc which terminates the rachis. This disc is very small in some species and appears to be formed in part by the united bases of the microsporangia as in *Telangium affine* (Pl. CI, fig. 1; Pl. CIV, fig. 5). In *Telangium bifidum* it is larger and forms a small quadrilobed flat shield-like disc 3 mm. in diameter, which may result from a coalescence of four short branches arising from an arrested double dichotomy, as indicated by its quadrilobate form (Pl. CII, fig. 6). In any case, it seems to be directly derived from the rachis and not from a modification of a pinnule. Both *Telangium affine* L. and H. sp. and *Telangium bifidum* L. and H. sp. are placed by Dr BENSON in *Telangium.*

In all the species included in *Telangium* here the fertile pinnæ are entirely deprived of sterile pinnules, and the restored drawing of a synangium of *Telangium Scotti* given by Dr BENSON on pl. xi, fig. 10 (*loc. cit.*), has a great similarity in external appearance to those of *Telangium affine* L. and H. sp. (Pl. CI, fig. 5).

None of the specimens of *Telangium Scotti* that I have examined showed any

* See *ante*, p. 4.

† BENSON, *loc. cit.*, p. 162. (There appears to be a mistake in the size given for the microspores by Dr BENSON.)

evidence of the microsporangia being attached to a reduced pinnule. Dr Scott, on the other hand, referring to Dr Benson's description of the synangia of *Telangium* being borne terminally on the ultimate ramifications of the rachis, states that "As a matter of fact the synangia in *T. Scotti* are often seated on a flat disc, which may be compared to a fertile pinnule of *Crossotheca*, so that the distinction between the genera is not always as marked as it appears at first sight" (*loc. cit.*).

In all the species of *Telangium* included here the microsporangia are attached to a disc, usually very small but, as already stated, larger in *Telangium bifidum*. Irrespective, however, of whether this disc represents a modified pinnule or an expanded tip of the rachis there are other very important points of difference which separate *Telangium* from *Crossotheca*.

In *Telangium* the microsporangia stand upright on the disc, continuing the line of the rachis, while in *Crossotheca* the microsporangia are attached to the lower surface of the modified pinnule and extend as a fringe beyond its margin. In *Telangium* the microsporangia are unilocular. In the only species of *Crossotheca* (*Hœninghausi*) in which the structure of the microsporangia is known (so far as I am aware) they are bilocular. On these grounds, if on no other, the genera *Telangium* and *Crossotheca* cannot be united.

Distribution.—In Britain the genus *Telangium* has been found in the Oil-Shale Group of the Calciferous Sandstone Series, the Lanarkian Series, and the Westphalian Series.

Telangium affine Lindley and Hutton sp.

Plate C; Plate CI; Plate CII, fig. 1; Plate CIV, fig. 5; text-figs. 41–43.

1832. *Sphenopteris affinis* Lindley and Hutton, "Fossil Flora," vol. i, pl. xlv.
1836. *Sphenopteris affinis* Hibbert, *Trans. Roy. Soc. Edin.*, vol. xiii, p. 178, pl. v, *bis*; pl. vi, fig. 4.
1857. *Sphenopteris affinis* Miller, "Testimony of the Rocks," p. 466, frontispiece.
1859. *Sphenopteris affinis* Anderson, "Dura Den: a Monograph of the Yellow Sandstone and its Remarkable Fossil Remains," p. 48, fig.
1876. *Sphenopteris affinis* Peach, *Trans. Bot. Soc. Edin.*, vol. xii, pp. 162, 187.
1877. *Sphenopteris affinis* Peach, *Quart. Journ. Geol. Soc.*, vol. xxxiv, p. 132, pl. vii; pl. viii, figs. 5–7.
1879. *Sphenopteris affinis* Schimper in Zittel, "Handb. d. Palaeont.," Abth. 2, "Palaeophytologie," p. 106, fig. 74.
1877. *Diplothmema affine* Stur, "Culm Flora," *Abhandl. k. k. geol. Reichsanst.*, Band viii, Heft 2, p. 230.
1886. *Calymmatotheca affinis* Kidston, "Catal. Palæoz. Plants in British Museum," p. 66.
1887. *Calymmatotheca affinis* Kidston, *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 145, pl. ix, figs. 18–22.
1901. *Calymmatotheca affinis* Vaffier, "Étude géol. et paléont. du Carbon inférieur du Mâconnais," *Ann. Univ. de Lyon*, Nouv. Sér. i (Sci. et Méd.), fasc. 7, p. 102, pl. i, figs. 1, 1*a*.
1904. *Telangium affine* Benson, *Ann. of Bot.*, vol. xviii, p. 164, pl. xi, fig. 12, text-fig. 33.
1906. *Telangium affine* Kidston, *Phil. Trans.*, Ser. B, vol. cxcviii, p. 430, text-fig. 10.
1914. *Telangium affine* Nathorst, "Foss. Flora d. Polarländer," Teil 1, Lief. 4, "Nachtrag z. Paläoz. Flora Spitzbergens," p. 21, pl. xv, figs. 30–32.

1829. *Sphenopteris linearis* Brongniart (*non* Sternberg), " Hist. des végét. foss.," p. 175, pl. liv, fig. 1.
1836. *Sphenopteris linearis* Hibbert (*non* Sternberg), *Trans. Roy. Soc. Edin.*, vol. xiii, p. 178, pl. vi, fig. 3.
1836. *Cheilanthites linearis* Göppert, " Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, Band xvii, p. 232. (Excl. ref. *Sternberg*.)
1878. *Staphylopteris ? Peachii* Peach, *Quart. Journ. Geol. Soc.*, vol. xxxiv, p. 131, pl. viii, figs. 1–3 (*non* fig. 4).

Description.—Pteridosperm. Frond oval, 45 cm. or more in length. Petiole straight, 1 cm. in breadth, and inflated into a slight bulbous expansion at base by which it is attached to the stem (or rhizome). Outer surface usually smooth, but in certain states of preservation it shows fine longitudinal striations and irregularly-placed short transverse elevations. The petiole dichotomizes and divides the frond into two equal but asymmetrical sections ; the rachis of each section also dichotomizes twice. Two sub-opposite primary pinnæ are borne on the rachis below the fork.

Sterile pinnæ : primary pinnæ of segments oblique, broadly lanceolate or deltoid-lanceolate, touching or overlapping at their margins, rachis straight, smooth or faintly striated longitudinally. As traced upwards, the primary pinnæ assume the form of pinnules at the apex of the frond. Secondary pinnæ alternate, rhomboidal-lanceolate, oblique, rachis straight, smooth or with fine longitudinal striations ; the upper secondary pinnæ gradually assume the form of pinnules. The pinnæ on the outer sides of the arms of the dichotomy of the petiole are longer than those within the fork. The two primary pinnæ below the fork are of larger size. Tertiary pinnæ rhomboidal, oblique, rachis straight and bearing 2–5 lateral pinnules and a terminal lobe.

Pinnules rhomboidal or fan-shaped, united to the rachis by a broad footstalk, the larger divided into 3–4 cuneate segments with bluntly rounded apices. The pinnule lobes vary greatly in the width of the segments from narrow to broadly cuneate. Terminal pinnule cuneate, simple or having one or two short lateral segments.

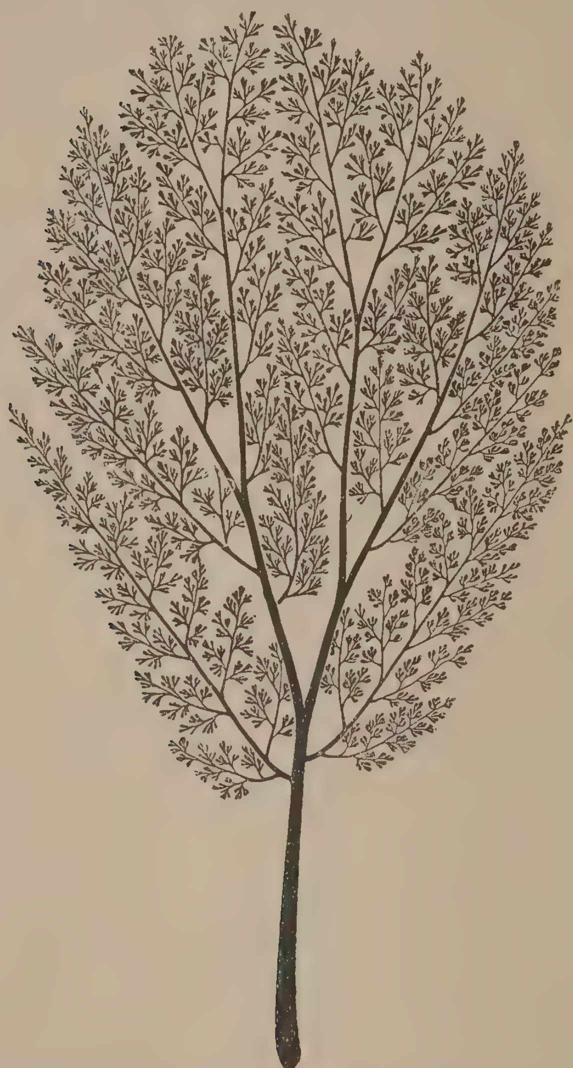
Nervation : a single vein enters the pinnules and immediately dichotomizes, and the two arms through repeated divisions produce a radiating series of veinlets of equal strength, two or more of which go to each segment of the pinnule.

Frond and pinnæ in young condition circinately coiled.

Fertile pinnæ : rachis of fertile pinnæ frequently dichotomizes at a wide angle and attains a breadth of 4 mm., smooth or with fine longitudinal striæ, deprived of foliage pinnules. The rachis terminates in two short dichotomies, and the four resulting arms each bear a little upright synangium. Synangia from 2·5 mm. to 3·5 mm. in length and 2·75 mm. to 3 mm. in breadth, the microsporangia are united to each other below and thus form a cup-shaped synangium, the lower part of which appears to form a solid base which merges into the top of the supporting rachis. Six sporangia seem to form a synangium. Microspores 52 μ in diameter, circular in outline, smooth, and provided with a small triradiate ridge. Seed not known.

Remarks.—The type specimen of *Telangium affine* figured by Lindley and

Hutton in their "Fossil Flora" (vol. i, pl. xlv) represents only one of the varying forms of their species, that with narrow pinnule segments. It may be compared with the specimen seen on our Pl. C, fig. 1, or Pl. CI, fig. 9, while that given by Brongniart under the name of *Sphenopteris linearis* (*non* Sternberg) illustrates the more characteristic form of the plant with broader pinnule segments (Pl. CI, fig. 8). Between these two forms, both in the size and the breadth of the pinnules and pinnule segments, an unbroken chain of intermediate forms can be traced, some having slightly larger and others smaller pinnules.



Text-fig. 41.—*Telangium affine* Lindley and Hutton sp. (Restoration of the frond drawn by Hugh Miller, 1857.)

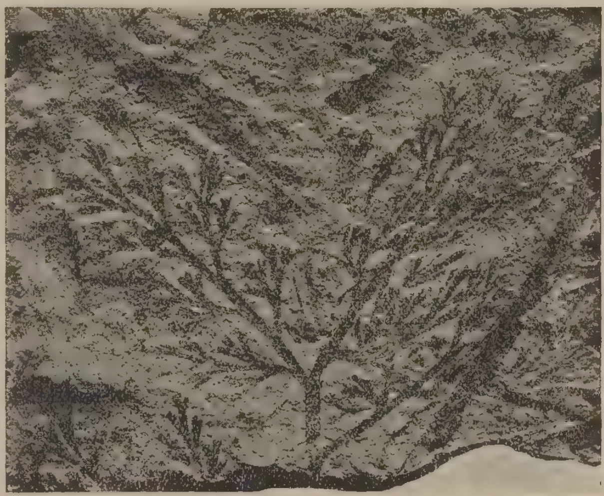
On Pl. CII, fig. 1, the basal portion of a frond is given natural size. It shows the complete length of the petiole and its dichotomy into two arms at the upper end. The base of the petiole gradually enlarges and terminates in a slight bulbous expansion, by which it was attached to the stem or rhizome, as the case may have been. The outer surface of the petiole on this example is quite smooth. This specimen also shows very beautifully the two sub-opposite primary pinnæ which spring from the rachis below the dichotomy.

Part of one of the two sections of a frond is given on Pl. C, fig. 2. It shows that the main rachis of the section underwent two dichotomies, and exhibits also the narrow-deltoid form of the secondary pinnæ.

The two examples just described are contained in the "Hugh Miller Collection," Royal Scottish Museum (Edinburgh), and are the two original specimens on which Hugh Miller founded his excellent restoration of the frond of "*Sphenopteris affinis*," which forms the frontispiece to his "Testimony of the Rocks." It gives an accurate representation of the structure of the complete frond and is reproduced here at text-fig. 41. I am indebted to Mr Alex. O. Curle, W.S., F.S.A., Director of the Royal Scottish Museum, for kind permission to figure these two interesting and historic specimens.

Another basal portion of a frond is given at fig. 1, Pl. C. This also shows the dichotomy of the petiole, the two sub-opposite primary pinnæ below the fork and the inflated termination to the petiole, but the outer surface of the rachis is here finely striated, not smooth as in the case of HUGH MILLER's specimen given on Pl. CII, fig. 1; and the impression of the base, where the petiole has been removed from the matrix, shows numerous small, transversely elongated bars, which have been elevations on the plant surface. Probably these and the striæ on the rachis have been exposed through partial decay of the cortex, and represent longitudinal bands and "nests" of sclerenchymatous tissue in the sub-epidermal region of the cortex. The "nests" are apparently a modification of the *Heterangium* type of cortex structure. The pinnæ seen at the base of the small slab containing this example have no organic connexion with the specimen, and their present position is accidental. Their pinnules, however, show the nervation very distinctly; this is seen also in the small fragment given natural size at fig. 6, Pl. CI, and in the enlarged pinnule seen on the same plate at fig. 6*a*.

Though it may have only occurred rarely, the pinnæ also seem to have divided dichotomously, as seen in the apical portion of the small specimen given at text-fig. 42. This, however, is the only example with dichotomously-divided lateral pinnæ that I have seen.



TEXT-FIG. 42.—*Telangium affine* Lindley and Hutton sp. Dichotomy of the apex of a pinna. Natural size. *Locality:* Burdiehouse, Midlothian. *Horizon:* Burdiehouse Limestone. Oil-Shale Group. Calciferous Sandstone Series. (Kidston Collection, No. 2006.)

To illustrate further the various forms of growth and pinnule segmentation, four other specimens are given natural size on Pl. CI, figs. 7–10. Reference has already been made to the tendency of the pinnules of ferns or fern-like plants, when preserved in oil-shale, to separate from the rock and become free.* These four specimens were collected by the late C. W. PEACH, who removed the plants from the surface of the oil-shale and mounted them between sheets of glass. They illustrate admirably the varying size of the pinnules on different specimens, and also the greater or less width of the pinnule segments. Fig. 7 may be part of a young or immature plant; fig. 9 shows the form with narrow pinnules, while fig. 8 gives the form of the pinnules most characteristic of the species. On fig. 10 the pinnules have narrow segments which are closely adpressed to each other, but this condition may have been brought about by some secondary cause such as pressure from a current of water passing over it before becoming completely imbedded.

A complete frond, in an early condition of development, is shown enlarged two

* *Ante*, pp. 171 and 220.

times at fig. 3, Pl. CI, and the impression of another and similar specimen is given at fig. 2. That at fig. 3 is remarkably perfect. It is 3·2 cm. in length, and shows the complete petiole with the slightly expanded base. The surface of the petiole bears fine longitudinal striations and is circinately coiled at the apex, where it bifurcates; the outer coiled arm of one of the forks partially obscures the other arm.

The second specimen, of which we have only the impression on the oil-shale, is given enlarged two times at fig. 2 and exhibits similar characters, but the two arms of the fork are individually more distinctly seen.

Portion of probably a primary pinna or perhaps one of the main sections of the frond is given at fig. 4, Pl. CI, also enlarged two times. Two lateral pinnæ and the termination of the rachis are in an undeveloped and circinately coiled condition.

Our knowledge of the fructification of *Telangium affine* is largely due to the painstaking labours of the late Charles W. Peach. All the specimens given here and others in my collection were collected by him. When he originally described the fructification of *Telangium affine,* he believed it to be a "parasite or an epiphyte" peculiar to the plant. What he regarded as the true fructification of *Sphenopteris affinis* L. and H., he figured in his paper read before the Geological Society of London in 1877.* The specimen from which this figure is taken is, I believe, in my collection (No. 640), but the "fruit" is merely the impression of the well-preserved epidermal cells of the pinnules on the matrix, which give them a roughened appearance.

The position of the fertile pinnæ on the frond of *Telangium affine* has not been ascertained, but it is probable that they were placed at the base of the frond as on *Telangium bifidum* L. and H. (see text-fig. 44, p. 457).

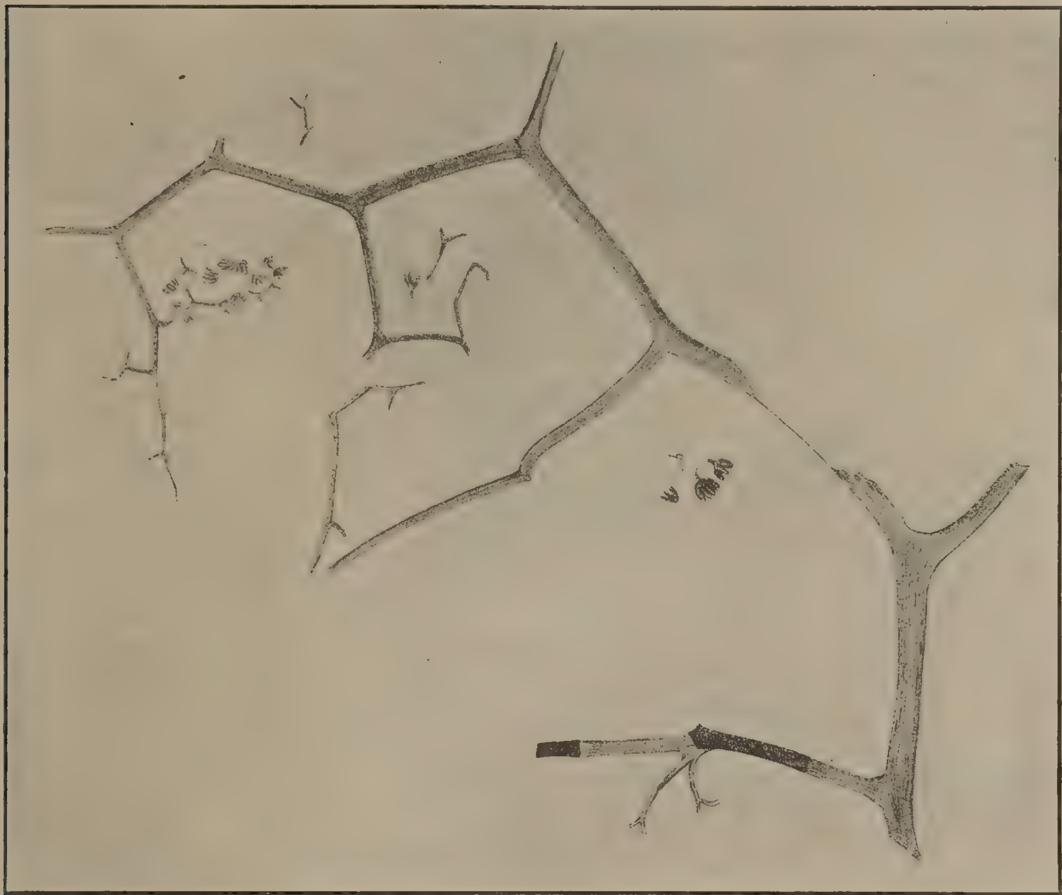
The rachis of the fertile pinnæ seems to have undergone repeated dichotomy. This is seen at text-fig. 43; most of the synangia, however, have fallen off. Part of a fertile pinna, enlarged two times, is given at fig. 1, Pl. CI. This exhibits very clearly the various degrees of dichotomy of the rachises, the arms of which separate at a wide angle. The last two dichotomous divisions of the rachis have comparatively short arms, and each arm bears at its summit a single upright synangium. These form little brush-like groups, the individual synangia of which often overlie one another. To show these points more distinctly, the same specimen as that given on Pl. CI, fig. 1, is enlarged two-and-a-half times at fig. 5, Pl. CIV. The sporangia are oblong-linear, with a blunt apex. Their walls are striated longitudinally. Generally each synangium exhibits four microsporangia and a single individual; this is particularly well seen at fig. 5, Pl. CI, enlarged four times. There were, therefore, probably six sporangia in each synangium, the other two being obscured by those in front of them. This figure also shows the basal union of the sporangia and the formation of the cup-shaded disc. The synangia always stand upright from the ends of their supporting branchlets. I have been unable to determine the mode of dehiscence of the microsporangia, but it probably took place by a longitudinal cleft passing down the inner surface. The split seen on the outer surface of one of the

* *Loc. cit.*, pl. vii, fig. 2.

microsporangia of the synangium given at fig. 5, Pl. CI, is an accidental break in its wall.

Some synangia were macerated and yielded oblong spore-masses. The spores had not reached mature development, but are globular, with smooth outer surface and a triradiate ridge. Their diameter is 52 μ. (Pl. C, fig. 3.)

The plant figured by LINDLEY and HUTTON under the name of *Sphenopteris*



TEXT-FIG. 43.—*Telangium affine* Lindley and Hutton sp. Fertile pinna natural size. *Locality:* West Calder, Midlothian. *Horizon:* Oil-Shale Group. Calciferous Sandstone Series. Collected by the late C. W. PEACH. (Kidston Collection, No. 637.)

linearis is not the same as that figured by BRONGNIART, STERNBERG, or FEISTMANTEL,* but an example of *Sphenopteridium crassum* L. and H. sp.†

To *Sphenopteridium crassum* the sterile condition of *Telangium affine* has a slight similarity, but in the former species the pinnules are more rhomboidal, have a greater number of segments and a more solid build. The type of nervation is the same in both plants, and it is on account of its fructification that *Telangium affine* is removed from the genus *Sphenopteridium.*

* "Verstein. d. Boehmischen Kohlen-Ablagerungen," Abth. 3, p. 60, pl. xvi, fig. 1, 1876.

† See *ante*, p. 168, pl. xxxix, figs. 1, 2, and 6.

Telangium affine is distinguished from *Diplotmema adiantoides* Schlotheim sp. by the deltoid form of the pinnæ and its less-divided pinnules. A comparison of the figure of *Diplotmema adiantoides*, Pl. LXIV, fig. 1, with the figures of *Telangium affine*, Pl. CI, figs. 6 and 6*a*, or those on Pl. CI, figs. 7–10, will show the distinctive differences of the two plants.

Under the name of *Sphenopteridium Schemnitzense*, STERZEL * appears to have included more than one species. That given on his pl. xiv, figs. 12*a* and 13, has a great likeness to *Telangium affine* L. and H. The specimen is small, but it is difficult to discover any distinctive character by which it can be separated from that species, especially the enlarged fig. 12*a*. This latter figure strongly suggests a possible specific identity. †

Distribution.—Telangium affine L. and H. sp. has only been recorded from the Oil-Shale Group of the Calciferous Sandstone Series, where it is very common and a most characteristic species.

CALCIFEROUS SANDSTONE SERIES.

OIL-SHALE GROUP.

Berwickshire.—*Horizon :* Sandstone and red ironstone band on horizon of Scremerston beds. *Locality :* Outcrop in slope above Cove Harbour, Cockburnspath (Collection of Geological Survey, Edinburgh).

Horizon : Shale resting on oil-shale band, about 2 feet above lowest Cove Limestone. *Locality :* Bay north-west of Cove, Cockburnspath.

Horizon : ?. *Localities :* Shore west of harbour, Cove, Cockburnspath ; Bilsdean Creek, 1½ miles west of Cockburnspath.

Dumbartonshire.—*Horizon :* ?. *Locality :* Escarpment on south side of Loch Humphrey Burn, where stream with waterfall enters, about ½ mile below the Loch.

Fifeshire.—*Horizon :* Burdiehouse Limestone. *Localities :* Grange Quarry, Burntisland ; Kilmundy Limestone Quarry, near Burntisland (Collection of Geological Survey, Edinburgh) ; Dodhead Quarry, near Burntisland (Collection of Geological Survey, Edinburgh) ; Shore, Rosyth (Collection of Geological Survey, Edinburgh) ; Brosyhall Limestone Quarry, east of Burntisland ; Inchkeith, Firth of Forth ; Flisk Quarry, Strathkennis, near St Andrews (Collection of Geological Survey, London) ; Right bank, Wakefield burn, ¼ mile north-east of Dunino Sawmill, Dunino, near St Andrews.

Horizon : A short distance above "Encrinite Bed." *Locality :* Shore, Breakboats, Pittenweem.

Horizon : ?. *Localities :* Roome Rocks, about ½ mile north-east of Crail (Collection of Geological Survey, Edinburgh) ; Rocks above Kinghorn ; Kemback

* STERZEL, "Organischen Reste d. Kulms u. Rothl. d. Gegens v. Chemnitz," *Abhandl. Math.-Phys. Kl. k. Sächs. Gesellsch. Wissensch.*, p. 214, 1918.

† His pl. i, fig. 12, seems to be a fragment of *Sphenopteridium pachyrrhachis* Göppert sp. *Cf.* GÖPPERT, "Foss. Flora d. Uebergangsgebirges," pl. xiii, fig. 4, 1852. See also *ante*, p. 164.

Quarry, Kemback (St Andrews Museum); West of Billowness (J. W. KIRKBY); Kilmundy Sandstone Quarry, near Burntisland (Collection of Geological Survey, Edinburgh); East side of the Binn, near Burntisland; Binn End Shale Works, Burntisland (Collection of Geological Survey, Edinburgh); Second Railway Cutting, east of Aberdour Railway Station; Railway Cutting No. 6, east of Aberdour Railway Station.

Haddingtonshire.—*Horizon:* Broxburn Oil-Shale. *Locality:* Shore, 700 yards south of Eyebroughty Scaur, Archerfield, Dirleton (Collection of Geological Survey, Edinburgh).

Horizon: Clayey Shale beds above Linkhead Limestone. *Locality:* Shore at Standalane, about ½ mile south-east of Linkhead, Innerwick (Collection of Geological Survey, Edinburgh).

Horizon: ?. *Localities:* Shore at Gullane Point, Gullane (Collection of Geological Survey, Edinburgh); West side of Gullane Point (Collection of Geological Survey, Edinburgh); Humbie Wood Old Sandstone Quarry, 6½ miles south-west of Haddington; Gifford Water at Old Mill, Slateford, 1 mile north of Gifford (Collection of Geological Survey, Edinburgh).

Lanarkshire.—*Horizon:* Twenty-one fathoms below Hurlet Limestone. *Localities:* Rotten Calder (Calderwood Glen), between East Kilbride and Blantyre (Collection of Geological Survey, Edinburgh); Cot Castle Farm, Avon Water, about ⅛ mile north of Strathaven (Collection of Geological Survey, Edinburgh).

Horizon: ?. *Locality:* Stream flowing into Mouse Water, Jerviswood, 1 mile north of Lanark (Collection of Geological Survey, Edinburgh).

Linlithgowshire.—*Horizon:* Under the Curley Oil-Shale. *Locality:* No. 1 Mine, Stewartfield, Broxburn (Professor H. BRIGGS).

Horizon: Below Burdiehouse Limestone. *Locality:* Shore, Dalmeny, half-way between Long Craig Pier and Newhall Pier (Collection of Geological Survey, Edinburgh).

Horizon: ?. *Localities:* Railway Cutting, Railway Station, Dalmeny; Shore, near Long Craigs Pier, Dalmeny; Shore, east of Newhall Pier, Dalmeny; Stream below Midhope, near Abercorn, 4 miles west of South Queensferry (Collection of Geological Survey, Edinburgh); Deans No. 2 Pit, about ¾ mile north-west of Livingston Railway Station (Collection of Geological Survey, Edinburgh); Pumpherston Shale Pit, ¾ mile west of Broxburn Railway Station (Collection of Geological Survey, Edinburgh).

Midlothian.—*Horizon:* Oil-Shales. *Localities:* Straiton Oil Works, near Loanhead; West Calder; Addiewell, West Calder; West Hermand, near West Calder (C. W. PEACH).

Horizon: Burdiehouse Limestone. *Localities:* Burdiehouse Limestone Quarry, 4½ miles south of Edinburgh; Raw Camps, Midcalder (Professor D'ARCY W. THOMPSON); Camps Quarry, Midcalder.

Horizon: Bed immediately below an oil-shale in face of Quarry, 10 feet below

Burdiehouse Limestone. *Locality:* Burdiehouse Limestone Quarry (Collection of Geological Survey, Edinburgh).

Horizon: Wardie Shales. *Localities:* Lochend, near Edinburgh; Water of Leith, below Dedhall Mill Dam (Collection of Geological Survey, Edinburgh); Hailes Quarry, Kingsknowe (T. Stock); Suburban Railway Cutting, Edinburgh (J. Gaul); Slateford (C. W. Peach); Railway Cutting, left bank, Water of Leith, half-way between Kate's Mill and Boag's Mill; Right bank Water of Leith, opposite Boag's Mill (Collection of Geological Survey, Edinburgh); Wardie shore, between tide marks, between Granton Pier and Chain Pier (Collection of Geological Survey, Edinburgh); Slaughter-house Boring, Slateford, at depths of 106 feet 6 inches, 270 feet, and 470 feet (Collection of Geological Survey, Edinburgh).

Horizon: Granton Sandstone. *Localities:* Granton Quarry, Granton; Granton Sea Quarry, Granton (Collection of Geological Survey, Edinburgh).

Horizon: Binny Sandstone. *Locality:* Whitehill Boring, West Calder (H. R. J. Conacher).

Horizon: ?. *Localities:* Harwood Burn, below Limefield House, near West Calder (Collection of Geological Survey, Edinburgh); Harwood Burn, 300 yards below double bridge under Limefield House, near West Calder (Collection of Geological Survey, Edinburgh); Right bank of Harwood Burn, about 200 yards below double bridge, Limefield House, near West Calder (Collection of Geological Survey, Edinburgh); Oakbank Sandstone Quarry, right bank of Limehouse Water, below Oakbank Oil Works (Collection of Geological Survey, Edinburgh); Bank of the Almond, Cramond; Murieston Water, right bank, ¼ mile south of Skibo, ¾ mile S.S.W. of Newpark Railway Station (Collection of Geological Survey, Edinburgh); Murieston Water, near Harburn, left bank of Stream (Collection of Geological Survey, Edinburgh); Burnhouse Boring, ¼ mile north-east of Raw Camps (Collection of Geological Survey, Edinburgh).

Northumberland.—*Horizon:* Oil-Shale between Woodend and Oxford Limestones. *Locality:* Shore, south of Spittal (Collection of Geological Survey, London).

Horizon: ?. *Locality:* Warksburn, North Tynedale (H. Miller).

Isle of Man.

Horizon: Black shales in the thick limestone, almost certainly on the horizon of the Oil-Shale Group of the Calciferous Sandstone Series. *Locality:* Ghaw Gortha, Poolvash (John Smith).

Telangium bifidum Lindley and Hutton sp.

Plate CII, figs. 5, 6; Plate CIII, figs. 1–9; text-fig. 44.

1832. *Sphenopteris bifida* Lindley and Hutton, "Fossil Flora," vol. i, pl. liii.
1836. *Sphenopteris bifida* Hibbert, *Trans. Roy. Soc. Edin.*, vol. xiii, p. 177, pl. vi, figs. 1, 2.
1857. *Sphenopteris bifida* Miller, "Testimony of the Rocks," p. 466, fig. 129.

1836. *Trichomanites bifidus* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, Band xvii, p. 264, pl. xv, fig. 11.
1884. *Calymmatotheca* (*Sphenopteris*) *bifida* Kidston, *Quart. Journ. Geol. Soc.*, vol. xl, p. 591.
1886. *Calymmatotheca bifida* Kidston, "Catal. Palæoz. Plants in British Museum," p. 68.
1887. *Calymmatotheca bifida* Kidston, "Fructification of some Ferns from the Carboniferous Formation," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 140, pl. viii, figs. 1–5, 6*a*; pl. ix, figs. 16, 17.
1894. *Calymmatotheca bifida* Nathorst (*pars*), "Foss. Flora d. Polarländer," Theil 1, Lief. 1, p. 19, pl. iii, fig. 3 (*non* figs. 1, 2).
1901. Cf. *Calymmatotheca bifida* Vaffier, "Étude géol. et paléont. du Carbon. inférieur du Mâconnais," *Ann. Univ. de Lyon*, Nouv. Sér. i (Sci. et Méd.), fasc. 7, p. 104, pl. i, figs. 3, 3*a*.
1901. *Calymmatotheca bifida* Kidston, "Flora of the Carboniferous Period," *Proc. Yorks. Geol. & Polytech. Soc.*, vol. xiv, pt. 2, pp. 190 and 205, pl. xxv, figs. 2, 3.
1904. *Calymmatotheca bifida* Kidston, "Fossil Plants of the Carb. Rocks of Canonbie," *Trans. Roy. Soc. Edin.*, vol. xl, p. 745.
1909. *Sphenopteris* (*Calymmatotheca*) *bifida* Zalessky, "Note sur les débris végétaux du terrain Carbonifère de la Chaîne de Mugodžary," *Bull. Comité géol.*, vol. xxviii, p. 8, pl. ii, fig. 2.
1911. Cf. *Calymmatotheca bifida* Nathorst, "Contributions to the Carboniferous Flora of North-Eastern Greenland," Danmark-Ekspedit til Grønlands Nordøstkyst, 1906–1908, vol. iii, No. 12, p. 342, pl. xv, figs. 5, 6.
1904. *Telangium bifidum* Benson, *Ann. of Bot.*, vol. xviii, p. 164.
1920. Cf. *Telangium bifidum* Carpentier, "Notes d'excursions paléobotaniques à Chalonnes et Montjean (Maine-et-Loire)," *Bull. Soc. géol. France*, 4e sér., vol. xix, p. 270, pl. viii, fig. 8.
1920. Cf. *Rhodea bifida* Májas, "Funde neuer Pflanzenreste aus dem Kulm von Chemnitz-Borna," *Bericht. d. Naturwiss. Abhandl. Gesellsch. zu Chemnitz*, xx, p. 63, pl. iii, fig. 5.
1883. *Sphenopteris rutæfolia* Schmalhausen (*non* Gutbier), "Die Pflanzenreste der Steinkohlenformation am Ostlichen Abhange des Ural Gebirges," *Mém. Acad. Imp. Sci. St Pétérsbourg*, Ser. 7, vol. xxxi, No. 13, p. 4, pl. i, figs. 1–3 (? 4, 5).
1875. *Todea Lipoldi* Stur, "Culm Flora," *Abhandl. k. k. geol. Reichsanst.*, Band viii, Heft 1, p. 71, pl. xi, fig. 8; Heft 2, p. 291.
1879. *Todea Lipoldi* Schimper in Zittel, "Handb. d. Palaeont.," Abth. 2, "Palaeophytologie," p. 107, fig. 75.
1876. *Sphenopteris* (*Trichomanites*) *frigida* Heer, "Beitr. zur foss. Flora Spitzbergens," *K. Svenska Vetenskaps-Akad. Handl.*, Band xiv, No. 5, p. 6, pl. i, figs. 1–6 (? fig. 28).
1883. *Staphylopteris Peachii* Kidston (*non* Balfour), "Fossil Plants collected in Eskdale and Liddesdale," *Trans. Roy. Soc. Edin.*, vol. xxx, p. 539, pl. xxxi, fig. 6.
1887. *Sorocladus antecedens* Kidston, "Fructification of some Ferns from the Carboniferous Formation," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 143, pl. viii, fig. 6*b*.

Description.—Pteridosperm. Frond of moderate size and attaining a probable length of 40 cm. Petiole stout, 6 mm. or more in width, and slightly expanded at base where attached to stem (or rhizome); dichotomizing and dividing the frond into two equal but asymmetrical sections. Surface of petiole with numerous short, close, transverse ridges. Sections of frond broadly lanceolate, contracting from about the middle to both base and apex, and terminating in a sharp point. Pinnæ opposite or sub-alternate; those borne on petiole below the dichotomy small and rudimentary, gradually decreasing in size as traced from the fork to the base. Sections of frond bipinnate; pinnæ lanceolate, those on outer side of fork longer than those within it. The larger of the outer pinnæ attain a length of 7 cm.; while those within the fork attain a length of only 4·5 cm. Rachis straight, narrowly winged. Pinnules alternate, of oblong contour, and divided into narrow-linear, truncate, or blunt-pointed segments, of which the larger pinnules have three opposite or alternate divisions and a terminal simple or dichotomous lobe, while the smaller have fewer divisions and the terminal ones are only bifid or reduced to a single segment. The limb of the pinnule forms a very narrow band on each side of the single vein.

Fertile pinnæ deprived of foliage pinnules. Rachis of pinnæ several times dichotomously divided, on the ultimate divisions of which are borne the synangia and seed cupules. Synangia when spread out horizontally measure 8·5 mm. in diameter, the disc to which the microsporangia are attached being about 3 mm. in width and of a quadrate form with rounded angles. Microsporangia upright, free, or united at their extreme base, linear, 2·5 mm. to 3 mm. in length and about 0·45 mm. in breadth, with 1–3 thread-like lines running up their dorsal surface. Each synangium bears about twenty-five microsporangia placed close to each other and united to the margin of the disc. The very numerous spores form a linear mass which terminates in a sharp point and has a rounded base. Spores circular, smooth, and 40 μ to 50 μ in diameter.

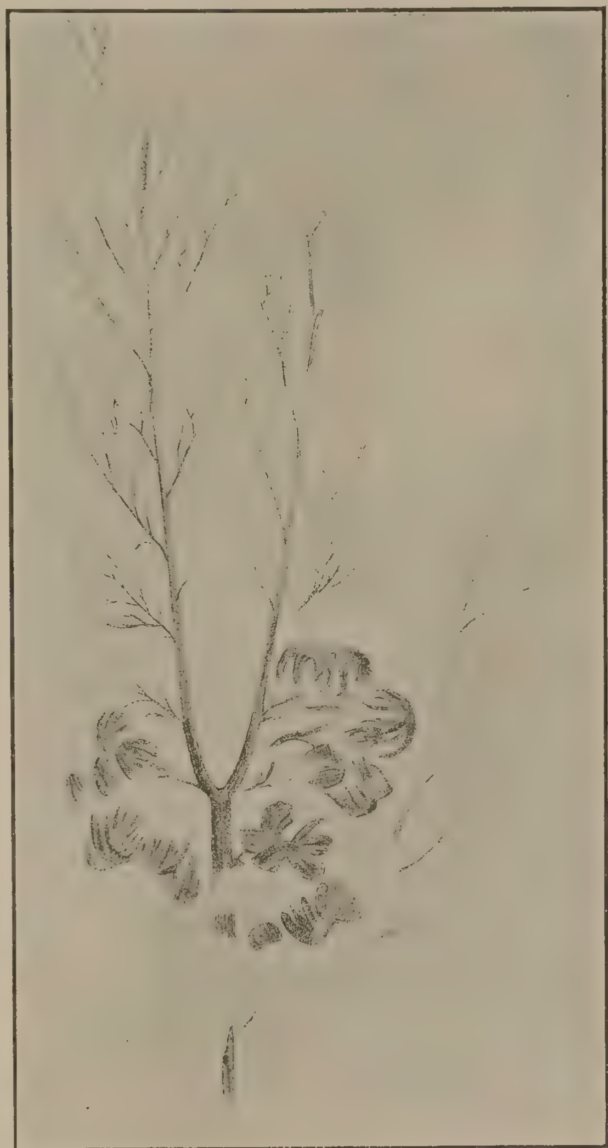
The cupule-bearing pinnæ are situated at the base of the two sections and on the petiole immediately below the dichotomy. The cupules are borne at the extremities of the ultimate divisions of the pinnæ and formed of five segments, which when spread out have a diameter of 1 cm. Seed not known.

Remarks.—The specimen of *Sphenopteris bifida* described by LINDLEY and HUTTON was imperfectly preserved and does not show the true characters of the species. These are seen on the well-preserved and almost complete example of one of the two sections into which the frond divides that is given natural size at fig. 1, Pl. CIII. It is contained in the "Hugh Miller" Collection, Royal Scottish Museum, Edinburgh; and I am indebted to the Director for permission to figure and describe it. A reduced but excellent figure of this specimen is given by HUGH MILLER in the "Testimony of the Rocks."

The pinnæ are opposite on this example and slightly oblique; those on the outer side of the fork are longer than those springing from the side of the rachis within the dichotomy. The former are broader, lanceolate, and the largest of them are widest towards the middle, whence they contract gradually into a sharp point. The pinnæ arising from the opposite side of the section are linear-lanceolate, of almost equal width till near the apex, where they also end in a sharp point. The pinnules are obliquely placed on the rachis, and the larger attain a length of fully 1 cm. (fig. 1*a*) and have three pairs of segments and a bifid terminal lobe. The segments are distant, very narrow, and consist of a midvein, with the limb reduced to a very narrow border on each side. The pinnules become smaller, and the segments are fewer as traced upwards (figs. 1*b* and 1*c*) and at the apex of the pinnæ are reduced to a single linear segment.

A basal portion of a frond is given at fig. 2, Pl. CIII. This is probably complete at its lower end, as it seems to terminate in a slight bulbous expansion by which it has been attached to the stem (or rhizome). The specimen shows the dichotomy of the petiole at its upper end, and extending downwards from this to the base is a series of opposite or sub-opposite pinnæ which decrease in size from above downwards. The rachis bears fine longitudinal striæ (most probably representing sclerenchymatous strands, but not seen on the figure on account of the direction of the illumination) and closely-placed, short, irregular, transverse bars.

A fertile specimen of *Telangium bifidum* is given at text-fig. 44. The sterile pinnules are much decayed and show little more than a few of the veins, but the firmer tissue forming the cupules has been better able to resist decay. These are borne on the pinnæ at the base of the rachis of the two segments and on the rachis below the dichotomy. If this specimen represents a frond, then it must have been much smaller than that seen at fig. 1, Pl. CIII, but it is possible that the sections of the frond may have dichotomized, for I possess a sterile specimen showing a dichotomy scarcely as large as that seen in the text-figure with well-formed pinnæ below the fork.* On the other hand, the fertile fronds may not have attained to the size of the sterile ones.



TEXT-FIG. 44.—*Telangium bifidum* Lindley and Hutton sp. Fertile specimen showing the pinnæ on which the seed-cupules were borne. *Locality:* River Irthing, near Waterhead, Cumberland. *Horizon:* Oil-Shale Group. Calciferous Sandstone Series. Natural size. (Kidston Collection, No. 718.) †

Empty seed-cupules were found plentifully on the surface of a bed at Lewis Burn, below Lewis Burn Colliery, North Tynedale, associated with synangia and sterile fragments of *Telangium bifidum*. A small specimen showing some empty spread-out cupules is given natural size at fig. 7, Pl. CIII. No seeds, however, were found with them.

* KIDSTON, *Proc. Yorks. Geol. & Polytech. Soc.*, vol. xiv, pl. xxv, fig. 3, 1901.

† The fragment of the large pinnæ seen on the ight of the text-fig. has no organic connexion with the rachis of the fertile specimen.

A fair number of specimens of synangia attached to fragments of pinnæ have also been found, but none in organic connexion with the frond. Two small specimens are given natural size at figs. 3 and 4, Pl. CIII. Fig. 3 shows a small dichotomously divided pinna with the synangia lying on the matrix at the extremities of the branchlets. At fig. 4 are also seen fragments of the rachises with the synangia clustered about their apices.

A group of four synangia, flattened out and seen from below, is given natural size at fig. 5, Pl. CII, and enlarged three and a half times at fig. 6 of the same plate. The disc to which the microsporangia are attached is quadrilobed and must have been of considerable consistence if one may judge by the thickness of the fragments of coaly matter which adhere to its impression. The four synangia represent the group borne at the extremities of the four ultimate short branches of the two last dichotomies of the rachis. Each synangium is composed of about twenty-five linear, free microsporangia which are attached to the margin of the disc. Each microsporangium has a thread-like band running up the middle, and usually two others can be seen passing up its surface close to the margins. Their mode of dehiscence has not been observed, but probably took place by a longitudinal cleft on their inner surface. As in the case of the cupules, the surface of some small blocks of stone was covered with groups of shed microsporangia ; a portion of one of these is seen natural size at fig. 6, Pl. CIII. The individual microsporangia can be seen if the figure be examined with a lens. As the discs seem to be absent and only rows of microsporangia are seen, the latter were probably united to each other at their bases. Some of these fallen microsporangia were macerated and yielded linear spore-masses, rounded at base and tapering to a sharp point at the apex ; two of these are seen at fig. 8, enlarged twenty-five times. A curious circumstance in connexion with these shed microsporangia is the apparent immaturity of the contained spores. The specimen shown at fig. 6 shows only about a quarter of the small slab on which they are scattered all over its surface. The spores are circular, with a smooth surface, and have a diameter of $40\,\mu$ to $50\,\mu$. A few are enlarged two hundred and fifty times at fig. 9.

With *Telangium bifidum* must be united *Sphenopteris frigida* Heer,* a view also held by NATHORST, who, however, has included two species among the specimens he figures under the name of *Calymmatotheca bifida* L. and H. sp. That on his pl. iii, fig. 3, is *Telangium bifidum*, but his figs. 2 and 3 of the same plate are *Rhodea tenuis* Gothan.† In *Rhodea tenuis* the pinnule segments are longer, more numerous, less spreading, and the frond has a much more "feathery" appearance. It lacks entirely the appearance of rigid growth that is characteristic of *Telangium bifidum*. The late Prof. NATHORST sent me specimens of the plant here referred to as *Rhodea tenuis* ; and I was thus enabled to compare them with examples of *Telangium bifidum*, from which I believe them to be essentially distinct.

To *Telangium bifidum* L. and H. sp. must also be referred *Sphenopteris rutæfolia*

* *Loc. cit.*

† "Oberschlesische Steinkohlenflora," Teil i, p. 15, pl. ii, fig. 2 ; pl. iii ; also see *ante*, p. 229.

Eichwald sp. (*non* Gutbier),* as figured by SCHMALHAUSEN.† This he says is the same plant as that given by EICHWALD under the name of *Gleichenites rutæfolius*,‡ which he states is a very inaccurate drawing of the specimen; and certainly EICHWALD'S figure represents a very different plant from that figured by SCHMALHAUSEN, and has no resemblance to *Telangium bifidum*.§

Todea Lipoldi Stur ‖ must also be united with *Telangium bifidum*. The differences on which STUR founded his species are due entirely to conditions of preservation.

Distribution.—Though *Telangium bifidum* L. and H. sp. is plentiful at some localities, and is less frequent in its occurrence than *Telangium affine* L. & H., its distribution is somewhat local. It is restricted to the Oil-Shale Group, of which it is also one of the most characteristic species.

CALCIFEROUS SANDSTONE SERIES.

OIL-SHALE GROUP.

Cumberland.—*Horizon:* Base of Lawston and Muirburn Coals, correlated with Scremerston Coal. *Localities:* River Irthing, $\frac{7}{8}$ mile north of Lampert (Collection of Geological Survey, London); Foot of stream, $\frac{3}{4}$ mile north-west of Wiley Syke, River Irthing (Collection of Geological Survey, London); River Irthing, 2 miles north-west of Waterhead (Collection of Geological Survey, London); River Irthing, 2 miles north-east of Waterhead (Collection of Geological Survey, London); River Irthing, $\frac{3}{4}$ mile east of Waterhead (Collection of Geological Survey, London); Foot of streamlet, 1 mile south-east of Wiley Syke, River Irthing (Collection of Geological Survey, London); River Irthing, 1 mile due north of Lampert (Collection of Geological Survey, London); Bothrigg Burn, near its head, 1 mile east of Flat, Bewcastle (Collection of Geological Survey, London).

Horizon: ?. *Localities:* Stream, between Oakshaw and Whintingstone, Clattering Ford, Bewcastle (Collection of Geological Survey, London); Whintingstone Burn, Clattering Ford, Bewcastle (Collection of Geological Survey, London); Whintingstone Burn, Black Line (Collection of Geological Survey, London).

Dumbartonshire.—*Horizon:* ?. *Locality:* Escarpment south side of Loch Humphrey Burn, where stream with waterfall enters about $\frac{1}{2}$ mile below the Loch.

Dumfriesshire.—*Horizon:* Base of Lawston and Muirburn Coals, correlated with

* *Sphenopteris rutæfolia* Gutbier ("Abdr. u. Verstein. d. Zwickauer Schwarzkohlengebirges," p. 42, pl. x, figs. 10, 11, 1835) is an entirely different species.

† "Pflanzenreste d. Steinkohlen. am Öst.-Abhange d. Ural-Gebirges," pl. i, figs. 1–3.

‡ "Lethæa Rossica," vol. i, p. 91, pl. ii, figs. 5, 6, 1860.

§ *Sphenopteris bifida* Schmalhausen, which he describes as a new species from the Permian Formation, is a distinct species, and not *Sphenopteris bifida* L. and H. The name has evidently been given through an oversight. ("Die Pflanzenreste d. Artinskischen und Permischen Ablagerungen im Osten des Europäischen Russlands," *Mém. Comité géol.*, vol. ii, No. 4, p. 35, pl. ii, fig. 20, 1887.)

‖ *Loc. cit.*

Scremerston Coals. *Locality:* Glencartholm, River Esk, Eskdale (Collection of Geological Survey, Edinburgh).

Fifeshire.—*Horizon:* ?. *Localities:* Ardross, about 1 mile north-east of Elie (T. KINNEAR); Railway Cutting No. 6, east of Aberdour Railway Station (Collection of Geological Survey, Edinburgh).

Haddingtonshire.—*Horizon:* Oil-Shale (? Broxburn). *Locality:* Shore, 700 yards south of Eyebroughty Scaur, Archerfield, Dirleton (Collection of Geological Survey, Edinburgh).

Lanarkshire.—*Horizon:* Nineteen fathoms below Hurlet Limestone. *Localities:* Rotten Calder (Calderwood Glen), between East Kilbride and Blantyre (Collection of Geological Survey, Edinburgh); Cot Castle Farm, Avon Water, about ⅛ mile north of Strathaven (Collection of Geological Survey, Edinburgh).

Midlothian.—*Horizon:* Burdiehouse Limestone. *Locality:* Burdiehouse, 4½ miles south of Edinburgh.

Northumberland.—*Horizon:* Base of Lawston and Muirburn Coals, correlated with Scremerston Coals. *Localities:* Plashetts Burn, North Tynedale (Collection of Geological Survey, London); Lewis Burn, Barney's Cut, about ¼ mile south-west of Lewis Burn Bridge, North Tynedale (Collection of Geological Survey, London); Lewis Burn, about 200 yards below Lewis Burn Colliery, North Tynedale (Collection of Geological Survey, London); Foot of Sauchie Syke, Little Whickhope Burn, North Tynedale (Collection of Geological Survey, London); Rigend Burn, Kielder, North Tynedale (Collection of Geological Survey, London); Little Whickhope Burn, near first branch above Cross Syke, North Tynedale (Collection of Geological Survey, London); Bateinghope Burn, 1 mile from head of stream, Redesdale (Collection of Geological Survey, London).

Horizon: Upper part of Fell Sandstones. *Localities:* Buck Burn, ¾ mile north-west of Willow Bog, Oakenshaw Burn, North Tynedale (Collection of Geological Survey, London); Cranecleuch Burn, opposite Cranecleuch New-Houses, Whickhope Burn, North Tynedale (Collection of Geological Survey, London).

Horizon: ?. *Localities:* Shore section, Sandstone Quarry, a little south of Seahouses, 4 miles north-east of Chathill (Collection of Geological Survey, London); Bateinghope Burn, 1 mile from head of stream, Redesdale (Collection of Geological Survey, London).

Roxburghshire.—*Horizon:* Base of Lawston and Muirburn Coals, correlated with Scremerston Coals. *Localities:* Kirshope Burn, Liddesdale (Collection of Geological Survey, Edinburgh); Tweeden Burn, Liddesdale (Collection of Geological Survey, Edinburgh).

ISLE OF MAN.

Horizon: Black shales in the thick limestone, almost certainly on the horizon of the Oil-Shale Group of the Calciferous Sandstone Series. *Locality:* Ghaw Gortha, Poolvash (JOHN SMITH).

Telangium digitatum Kidston n. sp.

Plate CXII, figs. 1, 1*a*.

Description.—Pteridosperm. Synangia 8 mm. in length, of which the disc is about 2 mm. in thickness and the microsporangia 6 mm. in length with a breadth of 1 mm.; free, except at their base, of almost equal width throughout, but contracted towards the apex and terminating in a sharp point. Synangia apparently developed in pairs at the extremities of a short-armed dichotomy. There were probably six microsporangia in a synangium.

Remarks.—The only specimen of *Telangium digitatum* that I have seen is the small example given natural size at fig. 1, Pl. CXII, and enlarged two times at fig. 1*a*. Of the two synangia shown, one is very imperfect, but they appear to have terminated two short arms of a dichotomy. As four microsporangia are exhibited, it is probable that their complete number in the synangium was six. Although the specimen is so fragmentary, it is interesting on account of the length of the synangia and the horizon from which it was obtained.

In *Telangium Scotti* Benson, also from the Lanarkian Series, the synangium was estimated to have been 5 mm. in length, whereas in our species its length is 8 mm.

Telangium digitatum was collected by the late A. MACCONOCHIE.

LANARKIAN SERIES.

LANARKSHIRE COALFIELD.

Horizon: Shale above Ell Coal. *Locality:* New Pit on roadside, ½ mile east of Baillieston (Collection of Geological Survey, Edinburgh, No. M. 2404A).

Telangium (?) Potieri Zeiller sp.

Plate CII, figs. 2–4.

1886. *Sphenopteris Potieri* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 88, pl. xiv, fig. 1.

1913. *Sphenopteris Potieri* Bertrand, "*Sphenopteris* du bassin houil. du Nord de la France," *Ann. Soc. géol. du Nord*, vol. xlii, p. 311.

Description.—Frond quadripinnate. Main rachis. . . . Primary pinnæ broadly lanceolate, rachis straight, longitudinally striated, and with a median gutter-like furrow limited by two parallel lines on its upper surface. Secondary pinnæ opposite or sub-opposite, lanceolate, slightly oblique to rachis, free or touching by their margins, somewhat broader towards the centre than at the base and contracting upwards to a point, rachis straight, with fine longitudinal striations and a median gutter-like furrow, winged. Tertiary pinnæ 1 cm. to 2 cm. in length, opposite or sub-opposite, broadly lanceolate and terminating in a blunt point; rachis straight, winged. The larger bear three or four pairs of sub-opposite pinnules and a blunt terminal lobe.

Pinnules decurrent, oblong-deltoid, obtuse, more or less contracted at base; on the larger tertiary pinnæ free and only connected by the wing of the rachis; on the smaller pinnæ the pinnules are united to each other to a greater or less extent; the former have a few prominent rounded lobes, the latter with much less prominent lobes or only undulating margins. Nervation consists of a thick median vein which dichotomizes at apex and gives off lateral thick veinlets which usually bifurcate; one of the resulting forks sometimes again divides. Fructification: the microsporangia belong to the type of *Telangium*. They form small groups of six or eight narrow tapering sporangia which occupy the place of the small pinnules. On the fertile pinnules the limb is very reduced or absent.

Remarks.—The only specimens of *Telangium Potieri* we have seen are a few fragments collected by Mr W. Hemingway from debris brought up during the sinking of the shaft of the Bradford Colliery, Manchester. Three of these are given on Pl. CII; figs. 2, 3 being natural size, and fig. 4 enlarged two times. Fig. 3 shows a portion of a secondary pinna from a lower position on a primary pinna than that seen at fig. 2. The tertiary pinnæ are short and the pinnules are united to each other for about one-third of their length, and have sinuous rather than lobed margins. Their rachis shows the characteristic gutter-like furrow running along its upper surface. Fig. 2 represents a specimen that probably held a higher position on a primary pinna, for the tertiary pinnæ have almost assumed the form of pinnules.

That given at fig. 4, enlarged two times, may have held a position on a primary pinnæ intermediate between figs. 2 and 3. These specimens, though small, exhibit the characteristic form of the segmentation of the pinnules on the upper tertiary pinnæ. On the lower-situated tertiary pinnæ the pinnules are slightly more distant, have more pronounced lobes, and were only united to each other by the wing of the rachis. Even the pinnules that stand most free from each other are connected to the rachis by a broad footstalk.

Though the nervation is strong and the veins thick, it is not often clearly seen, and seems to have been immersed in the tissue of the pinnule limb. The description of the fructification is that communicated to me by Professor Paul Bertrand in a letter. I have since had the opportunity of examining his fertile specimen, but I could not satisfy myself as to the mode of attachment of the Telangium-like groups of microsporangia to the fertile pinnule. They seemed to be associated with or attached to reduced pinnules, and if this is their true structure they differ in this respect from other members of the genus *Telangium* in which the limb of the pinnules is entirely absent and the microsporangia are attached to a disc at the end of the ultimate divisions of the rachis. Although *Sphenopteris Potieri* Zeiller is here included in the genus *Telangium*, it is not without some doubt that I assign this provisional position to it.

Telangium (?) *Potieri* Zeiller sp. is closely related to *Dicksonites Pluckeneti* Schlotheim sp., but the latter species differs from it in the rachis bearing numerous small blunt apiculæ, but these are not always present owing to imperfect preservation, and the rachis frequently shows only longitudinal striations. In *Dicksonites Pluckeneti* the pinnules are, however, more oblong and bear 2 or 3 pairs of very prominent rounded lobes, though in some conditions of the plant the pinnules are almost entire or have only sinuous margins. The differences appear slight in a verbal description, but when specimens are compared the two plants show themselves to be quite distinct specifically (see *ante*, p. 404, Pl. CIX).

Bertrand has pointed out * the great similarity between *Telangium ? Potieri* Zeiller and *Pecopteris Sterzeli* Zeiller,† especially with the figure of *Pecopteris Sterzeli* given by Zeiller,‡ on which it is difficult to discover any definite character by which it can be distinguished from his *Sphenopteris Potieri*. The rachises of the secondary pinnæ on this figure also seem to show gutter-like furrows on their upper surface.

I have examined the plant figured by Arber under the name of *Sphenopteris Potieri*,§ and find it is not Zeiller's plant but a somewhat imperfect example of a *Cyatheites-Pecopteris*.

I am indebted to Professor Paul Bertrand for the identification of my specimens, and also for a specimen of *Sphenopteris* (*? Telangium*) *Potieri* from the French Coalfield for comparison with the fragmentary British examples, which were collected by Mr W. Hemingway.

Distribution.—Very rare, and only known from the undernoted locality.

STAFFORDIAN SERIES.

Lancashire Coalfield.

BLACKBAND GROUP.

Horizon : From between 8 feet to 321 feet above the Bradford Four-foot Coal.
Locality : Bradford Colliery, Bradford, Manchester.

Note.—In a paper on the Fructification of Ferns from the Carboniferous Formation published in 1887,|| I recorded the occurrence of *Calymmatotheca asteroides* (=*Staphylopteris asteroides* Lesqx.)¶ from a specimen in the collection of the late Henry Johnson, of Dudley, of which the counterpart was also preserved.

While preparing the paper " On the Microsporangia of the Pteridospermeæ," ** I thought that possibly the record for *Telangium* (*Calymmatotheca*) *asteroides* might

* *Loc. cit.*, p. 311.

† *Pecopteris Sterzeli* Zeiller, " Études sur le terrain houil. de Commentry," vol. ii, " Flore Fossile," pt. 1, p. 178, pl. v, figs. 1–2 ; pl. vi, figs. 1–2 ; pl. vii, figs. 1–3 ; pl. viii, figs. 1–2 ; *Bull. Soc. Ind. min.*, 1888. Also " Bassin houil. et perm. de Blanzy et du Creusot," fasc. ii, " Flore Fossile," p. 59, pl. xiii, fig. 1, *Études des Gîtes Minéraux de la France*, 1906.

‡ " Bassin houil. et perm. de Blanzy et du Creusot," pl. xiii, fig. 1.

§ *Sphenopteris Potieri* Arber (*non* Zeiller), " Foss. Flora of Southern Portion of Yorkshire Coalfield," pt. ii : Derbyshire, *Proc. Yorkshire Geol. Soc.*, vol. xix, pt. 5, p. 354, pl. xxxix, figs. 2, 3, 1920. The specimens are preserved in the Sedgwick Museum, Cambridge, Nos. 2766, 2770.

|| *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 148.

¶ *Geol. Survey of Illinois*, vol. iv, p. 406, pl. xiv, figs. 6, 7 (*non* figs. 8–10, 1870) ; *Sorocladus asteroides* Lesquereux, " Coal Flora," vol. i, p. 328, pl. xlviii, figs. 9, 9A, 9B, 1879–80.

** *Phil. Trans. Roy. Soc.*, Ser. B, vol. cxcviii, p. 413, 1906.

have been made on an imperfect fertile specimen of *Crossotheca Hœninghausi* Brongniart sp., but at the time I was unable to trace the original specimen on which the record had been made. The species was therefore again included in the paper on "The Fossil Flora of the Westphalian Series of the South Staffordshire Coal Field," * under the name of *Telangium asteroides*.

Through the kind assistance of Mr W. N. Edwards, of the Geological Department of the British Museum, the original specimen on which the record for *Telangium asteroides* was founded has been discovered in the "Johnson Collection," which had been acquired by the British Museum. A re-examination of this specimen has shown that it is referable to *Crossotheca Hœninghausi*, but it is not so well preserved as those subsequently discovered and described in 1906. *Telangium asteroides* must therefore be removed from the list of British Carboniferous Plants.

I possess, however, a small specimen of a *Telangium* sp. (No. 2131), collected by Mr W. Hemingway at Woolley Colliery, Darton, near Barnsley, Yorkshire, from the roof of the Barnsley Coal, which agrees in the form and arrangement of the synangia with those of *Telangium asteroides* Lesquereux sp., but is smaller in all its parts than the figures given of that species, the microsporangia being rather less than 1 mm. in length. Though the structural details of the microsporangia and synangia can be observed, the synangia are so massed together that a photographic representation would not give a useful figure of the specimen.

Genus **Calymmatotheca** Stur (*pars*).

1877. *Calymmotheca* Stur (*pars*), "Culm Flora," Heft 2, *Abhandl. k. k. Geol. Reichsanst.*, Band viii, p. 149.
1883. *Calymmotheca* Stur (*pars*), "Morph. u. System. d. Culm-und Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. i, p. (799) 167.
1883. *Calymmatotheca* Zeiller, "Fructifications de Fougères du terr. houil.," *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, p. 182.

Description.—Seed-cupules borne at the extremities of the ultimate divisions of the frond, on which no foliage pinnules occur, coreaceous; at first closed but at maturity opening into four or six segments for the liberation of the seed. Seed and microsporangia not known.

Remarks.—It is extremely difficult to give a satisfactory description of the genus *Calymmatotheca*. Stur originally included in the genus a number of species of which the fructification was unknown. Some of these, through the subsequent discovery of their fructification or a better knowledge of its structure, have been placed in genera created for their reception. Stur, however, correctly interpreted the organs on which the genus is founded as a cup-like structure or cupule and not as microsporangia, a view adopted later by many palæobotanists.

The cupules sometimes have spine-like appendages, though more commonly they do not possess such.

* *Trans. Roy. Soc. Edin.*, vol. l, p. 96, 1914.

In one respect the genus *Lagenospermum* Nathorst * holds a close relationship to *Calymmatotheca* Stur. This genus was created for the reception of small seeds of spindle shape or elongated form which were enclosed in a cupule characterised by the presence of (six ?) strong longitudinal ribs. As types of his genus NATHORST cites *Lagenospermum Sinclairi* Kidston MS. Arber † and *Lagenospermum Arberi* Nathorst.‡ This, as a provisional genus, is useful in the present state of our knowledge of the seeds of Pteridosperms, for it embraces seeds with cupules varying in form and in minor details of structure.

Occasionally one meets with fragments of Pteridosperm fructifications, in which, on account of the condition of their preservation, it is difficult to determine whether they show the spread-out segments of a cupule or the microsporangia of a synangium; for the reception of these specimens Dr MARIE STOPES founded the genus *Pterispermostrobus*.§ This genus is dealt with later (see p. 473).

The three genera, *Calymmatotheca* Stur, *Lagenospermum* Nathorst, and *Pterispermostrobus* Stopes, are therefore intimately related, but their separate recognition is justified as a convenient means of cataloguing certain fossils until we obtain further knowledge of such Pteridosperm fructifications.

Distribution.—Calymmatotheca Stur, as here restricted, has been found only in Lower Carboniferous rocks in Britain, but there seems no reason why it should not be expected to occur in the Upper Carboniferous, where many Pteridosperms occur.

Calymmatotheca Stangeri Stur.

Plate CV, figs. 1–7; Plate CVI, figs. 1–9; Plate CVII, figs. 1–6; text-fig. 45.

1877. *Calymmotheca Stangeri* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. (151) 257, pl. viii–ix.

1883. *Calymmatotheca Stangeri* Zeiller, "Fructifications de Fougères du terr. houil.," *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, p. 183.

1883. *Calymmotheca Stangeri* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitz. k. Akad. Wissensch.*, Band lxxxviii, p. 801 (169), fig. 34.

1883. *Calymmotheca Stangeri* Renault, "Cours de botan. foss.," vol. iii, p. 198, pl. xxxiii, figs. 17–18.

1904. *Calymmatotheca Stangeri* Benson, *Ann. of Bot.*, vol. xviii, p. 161, pl. xi, fig. 11.

1903. *Sphenopteris Stangeri* Potonié, *Jahrb. k. preuss. geol. Landesanst.*, Band xxiii, Heft 3, p. 397.

1913. *Sphenopteris Stangeri* Gothan, "Oberschlesische Steinkohlenflora," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Band lxxv, p. 50, pl. x, fig. 1; pl. xvii, fig. 1.

1920. *Sphenopteris Stangeri* Gothan in GÜRICH, "Leitfossilien," Lief. iii, p. 38, pl. v, fig. 2.

1891. *Sphenopteris Hœninghausi* Potonié (*non* Brongt.) forma *Stangeriformis* Potonié, "Ueber einige Carbonfarne," Theil 2, *Jahrb. k. preuss. geol. Landesanst. fur 1890*, p. 25, pl. ix, figs. 2, 4, and 6.

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* NATHORST, "Zur Foss. Flora d. Polarländer," Teil 1, Lief. 4, "Nachträge z. Paläoz. Flora Spitzbergens," p. 29, 1914.

† "New Species of *Lagenostoma*," *Proc. Roy. Soc. London*, vol. lxxvi, B, p. 251, pl. ii, figs. 7–11, 1905; ARBER, *Radiospermum Sinclairi*, "Seed Impressions of the British Coal Measures," *Ann. of Bot.*, vol. xxviii, p. 103, pl. vii, figs. 33–34, 1914.

‡ NATHORST, *loc. cit.*, p. 30, pl. xv, figs. 18, 60–68.

§ M. C. STOPES, "'Fern Ledges' Carboniferous Flora of St John, New Brunswick," p. 76 (*Canada, Dept. of Mines, Geol. Survey Mem. 41*), 1914.

1877. *Calymmotheca Schlehani* Stur, "Culm Flora" (*op. cit.*), Heft 2, p. 174, pl. xi, figs. 2, 3, 4.
1913. *Sphenopteris Schlehani* Gothan, "Oberschlesische Steinkohlenflora" (*op. cit.*), p. 57, pl. xii, figs. 1, 3, 4.
1891. *Sphenopteris Hœninghausi* (*non* Brongt.) forma *Schlehaniformis* Potonié, "Ueber einige Carbonfarne" (*op. cit.*), Theil 2, p. 31, pl. ix, figs. 3, 5, 7.
1877. *Calymmotheca Rothschildi* Stur, "Culm Flora" (*op. cit.*), Heft 2, p. 176, pl. xi, fig. 5.
1903. *Sphenopteris dicksonioides* Potonié (*pars*), "Abbild. und Beschreib. foss. Pflanzen.," Lief. i, No. 2, fig. 1 (*non* fig. 2).
1908. *Sphenopteris Hœninghausi* Behrend (*pars*), "Uber einige Carbonfarne aus der Familie der Sphenopteriden," Inaugural Dissertation, p. 18. (See also *Jahrb. k. preuss. geol. Landesanstalt*, Band xxix, p. 660.)
1913. Cf. *Sphenopteris profunda* Gothan, "Oberschlesische Steinkohlenflora" (*op. cit.*), Teil 1, p. 67, pl. xii, fig. 2.

Description.—Pteridosperm. Stem 3 cm. or more in breadth, very long, supporting itself by scrambling amongst and holding on to surrounding vegetation by means of claspers. The cortex bears many spine-like emergences which occupy the centre of the meshes formed by a sub-epidermal rhomboidal reticulation of sclerenchymatous fibres. Petioles given off spinally, expanding at base where they join the stem, bifurcating and thus dividing the frond into two sections; the cortex of the petioles is similar to that of the stem and also bears numerous spine-like emergences. The rachises of the two sections of the frond undergo further dichotomies, and the frond as a whole is formed by a series of dichotomous divisions, all the axes of which are clothed with spine-like outgrowths. Foliage pinnæ borne on the petiole below its bifurcation and on the rachises of various degrees of the two main sections of the frond. The pinnæ on the petiole below its bifurcation are distant, speedily decrease in size, and cease some distance above its base. Pinnæ on arms of the sections linear-lanceolate or lanceolate; rachis straight or very slightly flexuous, usually free, sometimes touching at the margins, those on the inner side of the fork towards its base are shorter than those on its outer side; the lower-placed pinnæ are alternate or sub-opposite, bipinnate or tripinnate, the upper and smaller pinnæ frequently opposite and pinnate.

Pinnules alternate, sometimes opposite, very variable in form, convex, ovate, quadrate-ovate or triangular-ovate, entire or bear 2–4 more or less prominent rounded, convex lobes, whose separating sinus does not extend far inwards, contracted at base, and attached to the rachis by a broad footstalk.

The nervation is immersed in the thick tissue of the limb of the pinnule, and consists of a stout median vein which gives off lateral veinlets. In the larger pinnules these dichotomize twice and supply several veinlets to the larger lobes.

Fructification.—The seeds are borne on the ultimate divisions of the frond, on which no foliage pinnules occur. They are surrounded by a cupule formed of six segments nearly 1 cm. in length, which also bear spine-like outgrowths similar to those of the rachises on which they are borne. Seed (?): a small oval *Carpolithes* with smooth outer surface, about 2·25 to 2·50 mm. in length.

Microsporangia unknown.

Remarks.—Though not found at many localities in Britain, *Calymmatotheca Stangeri* was common at New Braidbar Quarry, Giffnock, and it occurred in very great abundance in a bed passed through in sinking the shaft of the Robroyston Colliery, near Bishopbriggs. A bed several inches thick was full of fragments of stems and parts of fronds. Very few other species were found in the bed, and the plant when growing seems to have formed a dense thicket composed almost entirely of *Calymmatotheca Stangeri*. The same has been observed in the case of *Diplotmema adiantoides* Schlotheim sp. (see p. 245) and *Diplotmema dissectum* (see p. 250), all of which had tall slight stems that seem to have grown in thick assemblages and so offered mutual support to one another. Another characteristic of the group is the dichotomy of the frond, and in the case of *Calymmatotheca Stangeri* a dichotomy of the rachises seems to have occurred more frequently than in its ally *Crossotheca Hœninghausi* Brongniart sp.

The extraordinary abundance of *Calymmatotheca Stangeri* at Robroyston offered a very favourable opportunity for studying the various forms assumed by the pinnules borne on pinnæ from different regions of the frond. This material has been supplemented by specimens from other localities, and the collection thus brought together has enabled us to illustrate the varying forms of the pinnules and their segmentation in the accompanying figures.

A part of a somewhat slender stem is shown natural size at fig. 1, Pl. CV, on which can be seen the bases of the spirally-placed petioles. At the centre of the stem towards the upper end a scar is exhibited, from which a petiole has been removed. At other parts of the stem the remains of petioles are seen projecting from the sides, or holding positions slightly inwards from its margin. On the greater part of the stem the cortex is more or less preserved; where complete, it shows the small scars left by the broken off spine-like emergences which are seen to spring from the centre of rhomboidal areas, formed by the anastomozing sub-epidermal sclerenchymatous strands. When the cortex is fully preserved the meshes are not so distinctly seen as when it has partially decayed or the outer layer been removed. A small portion of a stem in the latter condition is given on the same plate, fig. 2, enlarged two times, where the impression of the meshes is very well exhibited. At the upper end a petiole is passing out. The largest stem we examined was slightly under 2 cm. in breadth, but one figured by Stur has a width of nearly 3 cm.*

The stem, petiole, and rachises of various degrees all bear numerous spine-like outgrowths. These are usually buried in the rock and are broken over in splitting the stone, but occasionally one sees them projecting from the sides of the stems or rachises, on the surface of the matrix. Portion of a rachis, enlarged two times at fig. 9, Pl. CVI, shows some spines projecting from its edges. They have a slight downward curvature, a character well seen on Stur's fig. 1, pl. ix, and also on our fig. 9, Pl. CVI. The longest spine on this example is rather over 2 mm. in length.

Many fragments of dichotomously divided pinnæ were met with at Robroyston.

* *Loc. cit.*, pl. viii, fig. 1.

One of these is given on Pl. CV, fig. 4, and another on Pl. CVI, fig. 3. The usual angle of divergence of the arms of the dichotomies is about 50°.

Reference has already been made to the great variability in the size and form of the pinnules, according to the position on the frond of the pinnæ bearing them. The fragment of the bipinnate pinnæ shown on Pl. CV, fig. 5, and the tripinnate pinnæ given on Pl. CVI, figs. 1 (left-hand pinna) and 2, represent the plant figured by Stur as *Calymmatotheca Stangeri*. At fig. 5, Pl. CV, the pinnules are small, spring from the rachis at almost right angles, and the lower have usually three blunt lobes, though the distal basal pinnule has sometimes four lateral lobes, but as traced upwards the pinnules gradually lose their lobes and become entire. On the tripinnate pinna given at fig. 2, Pl. CVI, the ultimate pinnæ are short, the basal pinnules are feebly trilobate, and the upper are entire. On the part of a bipinnate pinna seen on the right of fig. 1 of the same plate, the pinnules are trilobate till near the apex, where they become entire. On the fragment of the dichotomous pinnæ on the left side of the same slab, the pinnules are larger but of the same form.

Calymmotheca Rothschildi Stur is generally admitted to be referable to his *Calymmotheca Stangeri*, from which it does not really differ in any point. It is similar to the small specimen from which a few pinnules are enlarged on Pl. CVII, fig. 6, or the upper portion of the right-hand pinna seen on fig. 1, Pl. CVI.

With *Calymmatotheca Stangeri* I also unite the *Calymmotheca Schlehani* Stur (*Sphenopteris Schlehani* Gothan, *loc. cit.*). This form of the plant is seen on Pl. CV, fig. 7, and on Pl. CVI, figs 3, 6, and 8, the latter two being enlarged two times on Pl. CVII, figs. 3 and 5. Our fig. 7, Pl. CV, and fig. 3, Pl. CVI, are indistinguishable from Stur's figure in the "Culm Flora" (pl. xi, fig. 4) and that given by Gothan under the name of *Sphenopteris Schlehani* in his "Oberschlesische Steinkohlenflora" (pl. xii, fig. 1). Our fig. 4, Pl. CV, only differs in the ultimate pinnæ being longer. The pinnules are of the same form on the greater extent of the pinnæ, though a few of them are feebly lobed at their base. This example and others such as that seen at fig. 4, Pl. CV, so connect the *Calymmotheca Schlehani* Stur with his *Calymmotheca Stangeri* that I find it impossible to discover any character by which they can be distinguished. There is also seen in the small fragment given at Pl. CVI, fig. 7, enlarged two times at fig. 4, Pl. CVII, another connecting link which seems very similar to the small fragment given by Gothan.* Our fig. 6, Pl. CV, also corresponds with Gothan's figure of *Sphenopteris Schlehani* given on his pl. xii, fig. 3 (*loc. cit.*), but it is of slightly larger form.

The specimen given on Pl. CVII, fig. 1, natural size, of which a part is enlarged two times at fig. 1*a*, seems to be the *Sphenopteris profunda* Gothan.† I am satisfied that our specimen is only a somewhat larger-pinnuled form of *Calymmatotheca Stangeri*. The more complete specimen figured by Gothan has all the outstanding characters of that species and seems to differ only in the larger size of the pinnules, but both at Robroyston and Braidbar Quarry large-pinnuled specimens occurred in association

* *Loc. cit.*, pl. xii, fig. 4.

† "Oberschlesische Steinkohlenflora," pl. xii, fig. 2.

with those having pinnules of the usual smaller size, and these larger-pinnuled examples I feel sure, in the case of the Scottish specimens at least, are only individual variations of growth and do not represent a distinct species. Two small fragments illustrating these larger-pinnuled forms from Braidbar Quarry are given at figs. 4 and 5, Pl. CVI, the latter being enlarged two times. In both cases, except in the size of the pinnules being slightly larger than those usually met with on this species, they appear to differ in no respect from typical specimens of *Calymmatotheca Stangeri.*

The nervation has apparently been immersed in the thick tissue of the pinnules and is seldom clearly exhibited. It is seen at fig. 5, Pl. CVI, though not very distinctly, enlarged two times. The median vein is thick and gives off lateral veinlets, which, in this case, usually bifurcate two times. The veins in the small-pinnuled forms are very seldom clearly exhibited, but are seen in the specimen given on Pl. CVI, fig. 6, natural size, and enlarged two times on Pl. CVII, fig. 3. The vein here seems to divide immediately on entering the pinnule.

Among the specimens of *Calymmatotheca Stangeri* found at Robroyston many of the pinnæ had the appearance as if their upper portions had not reached maturity and were in a young condition of growth, for though the lower part of the pinnæ was well preserved, the preservation became gradually more and more imperfect as traced upwards, and the extreme tip was seldom shown. On one specimen the extreme apex was preserved and ended in a well-developed clasper. It is shown natural size at fig. 3, Pl. CV. The clasper forms a bar 3 cm. in length, lying at right-angles to the rachis, which it terminates. Each end again divided at right-angles to the bar, but only one of the resulting arms is preserved ; this is seen at the upper side at the right-hand end of the transverse bar. It is about 6 mm. in length and terminates in a semicircular hook. The base of the corresponding hook on the other side can also be seen.

Prof. SEWARD * refers to the presence of peculiar " tendril-like appendages " on the pinnæ of *Gleichenia hantonensis* from the Eocene beds of Bournemouth, described by GARDNER and ETTINGSHAUSEN.† In the figure given by SEWARD the " tendril-like appendages " are situated at the base of the pinnæ, not at their apices as on *Calymmatotheca Stangeri.* The latter, so far as I am aware, is the first record of a Palæozoic plant (in this case a Pteridosperm) provided with well-developed claspers.

That *Calymmatotheca Stangeri* needed to support itself by scrambling amongst neighbouring vegetation is evident from the nature of its stem, which is too slender in proportion to its length to have grown upright ; but that it held an upright position is shown by the spiral arrangement of its fronds. By the aid of claspers the maintenance of an upright position would be easily achieved.

Along with the specimens of *Calymmatotheca Stangeri* found at Robroyston were young cupules attached to the extremities of ultimate divisions of the frond,‡ but

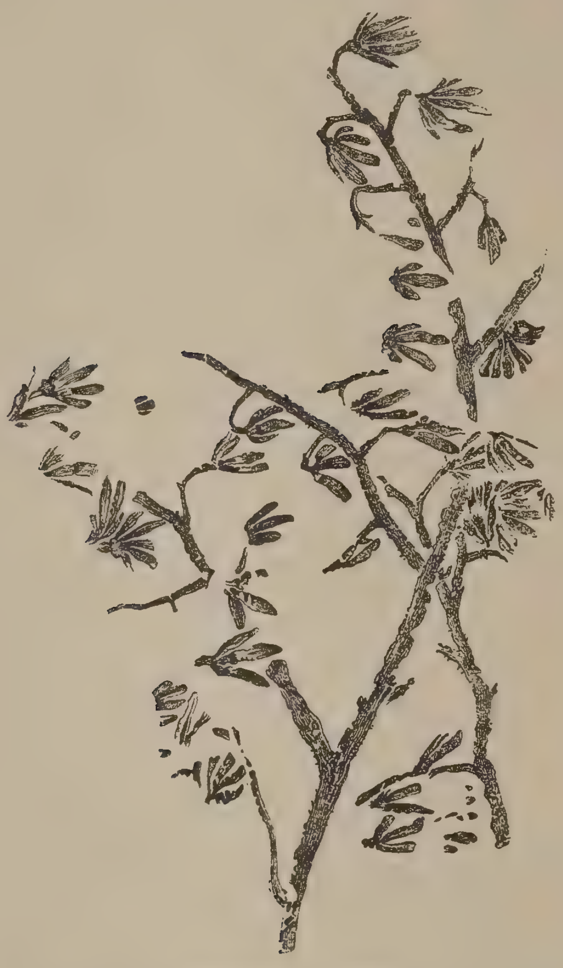
* " Fossil Plants," vol. ii, p. 355, fig. 263, 1910.

† " Monograph of the British Eocene Flora," vol. i, " Filices " (*Palæont. Soc. London*), 1882.

‡ Kidston Collection, Nos. 5620 and 5622.

they do not show the structure so well as the figure given by STUR, reproduced here in text-fig. 45. A cupule broken transversely, however, showed that it was formed of six segments.*

A small part of a very interesting specimen is given on Pl. CVII, fig. 7, enlarged two times. This example shows fragments of *Calymmatotheca Stangeri* and at one corner a patch of small *Carpolithes* seeds. They are oval, have a smooth surface, and measure from 2·25 mm. to 2·50 mm. in length. It is extremely probable that these are the seeds of *Calymmatotheca Stangeri* Stur.



TEXT-FIG. 45.—*Calymmatotheca Stangeri* Stur. Fertile pinnæ showing cupules from which the seeds have been removed. Natural size. (Copied from STUR.)

M. E. BUREAU † figures and describes some specimens under the name of *Calymmatotheca Dubuissonis,* with which he unites *Calymmatotheca Stangeri* Stur. His specimens agree well with BRONGNIART'S enlarged figure of the pinnules of *Sphenopteris Dubuissonis,*‡ but I am very doubtful about BRONGNIART'S species being specifically identical with *Calymmatotheca Stangeri* Stur. The pinnules are more oblique to the rachis and have more pointed lobes in BRONGNIART'S plant than in STUR'S species. They are allied species, but I do not think, so far as one can judge from figures, that they are specifically identifiable.§

POTONIÉ (*loc. cit.*) reduced *Calymmatotheca Stangeri* and *Calymmatotheca Schlehani* Stur to the rank of varieties of *Sphenopteris Hœninghausi* Brongniart. Although related to each other, *Calymmatotheca Stangeri* and *Crossotheca Hœninghausi* Brongniart sp. are essentially distinct in the form of their pinnules, which in the latter do not reach even nearly the size of those of *Calymmatotheca Stangeri*. The two species, moreover, have an individual character which is difficult to express in words but is

* Kidston Collection, No. 5621.

† "Bassin de la Basse Loire," fasc. ii, "Flores fossiles," p. 254, pl. x, fig. 1 to 1D; pl. xi, figs. 3, 3A; pl. xii, figs. 1–3. (*Études Gîtes Mineraux de la France*, 1914.)

‡ "Hist. des végét. foss.," p. 195, pl. liv, figs. 4, 4A.

§ See also notes on this subject in GOTHAN, "Oberschlesische Steinkohlenflora," Teil i, p. 44 (footnote). The seed in cupule referred to by GOTHAN in note at foot of p. 45 is not mentioned in the description of *Calymmatotheca Stangeri* given above, as some doubt exists as to its organic connexion with the specimen of *Calymmatotheca Stangeri* beside which it occurs.

clearly observable to the eye. A comparison of the figures of the two species given in this memoir will show this better than a verbal description.

Distribution.—In Britain *Calymmatotheca Stangeri* Stur has only been recorded from the Upper Limestone Group of the Carboniferous Limestone Series.

CARBONIFEROUS LIMESTONE SERIES.

UPPER LIMESTONE GROUP.

Horizon: Immediately underneath the Orchard Limestone. *Locality:* New Braidbar Quarry, Giffnock, Renfrewshire.

Horizon: About 35 feet below Orchard Limestone. *Locality:* Shaft Sinking, Robroyston Colliery, $1\frac{3}{4}$ miles south-east of Bishopbriggs, Lanarkshire.

Horizon: Lower part of Millstone Grit, 70 to 80 yards above Castlecary Limestone. *Locality:* Quarry, Garngad Road, Glasgow, $\frac{1}{6}$ mile east of Garngad Railway Station (Collection of Geological Survey, Edinburgh).

Horizon: About position of Castlecary Limestone. *Locality:* Diamond boring, Rashiehill, Slamannan, Stirlingshire (Collection of Geological Survey, Edinburgh).

Horizon: Lower part of Millstone Grit. *Locality:* Caar Water, Dalry, in stream bank, 290 yards down from Drumastle Mill, Ayrshire.

Horizon: Yoredale Beds. Probably on the horizon of the Upper Limestone Group. *Locality:* Thirstfield, Grassington, Wharfedale, Yorkshire (W. Hind).

Genus **Diplotheca** Kidston.

1903. *Diplotheca* Kidston, "Summary of Progress for 1902," *Mem. Geol. Survey*, p. 131.
1906. *Diplotheca* Kidston, *Phil. Trans. Roy. Soc.*, Ser. B, vol. cxcviii, p. 430.

Description.—Synangium composed of several microsporangia joined to each other in pairs at their lower ends and attached to a common disc-like plate.

Remarks.—At first sight these synangia might be mistaken for split cupules, but an examination of the specimens at once dismisses this interpretation of the fossils. That the structures are not the segments of split cupules is shown by the regularity of all their parts,—the clearly defined rounded sinus which separates the two microsporangia at their point of union, the distinctly defined margins of the microsporangia, and the equality of their free portions. The microsporangia are faintly striated longitudinally with very short striæ which seem to indicate the elongated cells that form their walls.*

The fructification described by Stur † as *Calymmotheca Haueri* I include in the

* In *Stangeria* some of the sporangia remain for a time united in pairs: W. H. Lang, "The Microsporangia of *Stangeria paradoxa*," *Ann. of Bot.*, vol. xi, p. 245, 1897.

† "Culm Flora," Heft 1, p. 51, pl. i, fig. 2, 1875 ("Fruchtstand eines Farnes"); Heft 2, p. (149) 255, 1877 (*Calymmotheca Haueri*).

genus *Diplotheca.* The differences between it and *Diplotheca stellata* are only specific.

Distribution.—Very rare, and known from only one locality in Britain, situated on the Limestone Coal Group of the Carboniferous Limestone Series.

Diplotheca stellata Kidston.

Plate CIV, figs. 1, 1*a*, 2.

1903. *Diplotheca stellata* Kidston, " Summary of Progress for 1902," *Mem. Geol. Survey*, p. 131.
1906. *Diplotheca stellata* Kidston, *Phil. Trans. Roy. Soc.*, Ser. B, vol. cxcviii, p. 430, text-fig. 11.

Description.—Synangium formed of ten linear, sharp-pointed microsporangia 1 cm. in length and slightly more than 1 mm. in breadth at the widest part, united to each other in pairs at their base for a distance of 1 mm., after which the five geminate pairs of microsporangia join on to a central disc. Sterile condition of plant unknown.

Remarks.—Two specimens of this fructification, which I believe to belong to the Pteridosperms, are shown on Pl. CIV, figs. 1 and 2. Fig. 1 shows two of the microsporangia in a complete condition. This specimen is enlarged two times at fig. 1*a*. The microsporangia are 1 cm. in length and about 1 mm. in breadth at their widest part, which is at a distance of about two-thirds their length above their base. At their base they unite in pairs, and the united portion joins on to a central disc.

Only three specimens were found, showing in all the remains of four synangia, and each synangium was formed of five geminate pairs of microsporangia. The two microsporangia of each pair bend towards each other till their apices are brought close to each other.

Fig. 2 shows two synangia, of which the upper portions of all the geminate microsporangia are broken off, but the basal portions of some of the pairs have a slight inward curvature. No organic connexion could be traced with the stem, which separates the synangia on this specimen, and their position in regard to it may be accidental. Under the microscope the surface of the microsporangia shows indications of their walls having been formed of elongated cells.

This species is easily distinguished from *Diplotheca Haueri* Stur sp.* by its much longer and slightly fusiform microsporangia, which in Stur's *Calymmotheca Haueri* are shorter and their free portion is of narrow-triangular form.

All the specimens were collected by the late A. Macconochie, and are in the Collection of the Geological Survey, Edinburgh (Nos. M. 3172e, M. 3173e, and M. 3174e).

Distribution.—Very rare and only known from the locality mentioned below.

* *Calymmotheca Haueri* Stur, " Culm Flora," Heft 2, p. (255) 149 ; Heft 1, p. 51, pl. i, fig. 2.

CARBONIFEROUS LIMESTONE SERIES.

LIMESTONE COAL GROUP.

Horizon: Shale interbedded in sandstone. *Locality:* Machrihanish Water, 320 yards west from Wimbledon Pit, near Campbeltown, Argyllshire.

Genus **Pterispermostrobus** Stopes.

1914. *Pterispermostrobus* Stopes, "The 'Fern Ledges' Carboniferous Flora of St John, New Brunswick," *Canada Dept. of Mines, Geol. Survey Memoir 41*, p. 74.

Description.—Fructifications of Pteridosperms that cannot be associated with a known species of parent and that may be either seeds or male organs borne on a definitely branching rachis.

Remarks.—Owing to imperfect preservation, it is sometimes very difficult or even impossible to determine whether some Pteridosperm fructifications represent synangia bearing upright microsporangia or cupules split into narrow segments, and for these Dr MARIE STOPES created the provisional genus *Pterispermostrobus.*

Such doubtful Pteridosperm remains are therefore placed in it until their true nature is discovered.

Pterispermostrobus sp.

Plate XXXIX, fig. 6 (*pars*); text-fig. 46.

Remarks.—A small fragment of a pteridospermous fructification is shown natural size at fig. 6, Pl. XXXIX, where indicated by a pointer, and is enlarged three and a half times at text-fig. 46.

The state of preservation of this specimen does not permit of its being satisfactorily determined, whether the fossil shows cupules split into segments or synangia bearing upright microsporangia. The structures, whatever their true nature may have been, are borne at the extremities of stout, dichotomously-divided branchlets.

TEXT-FIG. 46.—*Pterispermostrobus sp.* Enlarged three and a half times. (Kidston Collection, No. 5313.)

The most perfect individual of the group exhibits a campanulate structure 4 mm. in length and 3 mm. in breadth, divided into five teeth-like points. These, as shown on the specimen to the right, seem to be free till near the base (text-fig. 46, *a*), and have very much the appearance of microsporangia. On the other hand, the better-preserved example looks like a cupule split into segments, but this may be caused by the microsporangia (if such they be) lying close to each other and thus obscuring their individuality. I think that the fossil more probably represents imperfectly-preserved synangia, but as it is quite possible that it shows the remains of cupules, it finds its place in *Pterispermostrobus* Stopes, a genus created for the reception of such doubtful pteridospermous remains.

Distribution.—The small specimen figured is the only example of this fructification known to me.

CALCIFEROUS SANDSTONE SERIES.

OIL-SHALE GROUP.

Horizon: ?. *Locality:* Escarpment south side of Loch Humphrey Burn where waterfall enters stream, about ½ mile below the Loch, Dumbartonshire.

Fertile Fragment of a Fern or Fern-like Plant.

Plate CIV, fig. 4.

1888. *Sphenopteris sp.* Kidston, "Foss. Flora Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 411, pl. xix, fig. 3.

Remarks.—The small fertile specimen given natural size on Pl. CIV, fig. 4, shows a few imperfect pinnæ bearing alternate pinnules. These are divided into 2–3 pairs of oblique linear segments and a terminal lobe of the same form, at the extremity of each of which is borne an oval sporangium about 1 mm. in length. The fossil is preserved as a carbonaceous film on the matrix in which the sporangia have impressed little pits. They show no structural details. The rachis has fine longitudinal striations.

The specimen has a considerable resemblance to the fertile portion of *Diplotmema Zeilleri* Stur,* but differs in that the pinnule segments are linear and free from each other, whereas in *Diplotmema Zeilleri* the pinnule segments are sub-triangular and united by their basal portions.

Distribution.—The specimen figured is the only example I have seen.

RADSTOCK SERIES.

SOMERSET AND BRISTOL COALFIELD.

FARRINGTON GROUP.

Horizon: ?. *Locality:* Farrington Gurney, 7½ miles north of Shepton Mallet, Somerset.

Genus **Senftenbergia** Corda.

1845. *Senftenbergia* Corda, "Flora d. Vorwelt.," p. 91.
1849. *Senftenbergia* Brongniart, "Tableau des genres de végét. foss.," *Dict. univ. d'Hist. nat.*, p. 28.
1850. *Senftenbergia* Unger, "Genera et Species Plant. Foss.," p. 210.
1869. *Senftenbergia* Schimper, "Traité de paléont. végét., vol. i, p. 578.

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* *Sphenopteris acutiloba* Zeiller (*non* Sternb.), *Ann. Sci. Nat.*, 6e sér., Bot., vol. xvi, pp. 199, 209, pl. xi, figs. 2–5, 1883; *Diplothmema Zeilleri* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl k. k. geol. Reichsanst.*, Band xi, Abth. i, p. 329, 1885; *Diplothmema Zeilleri* "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 151, pl. xv, fig. 5; pl. xvi, figs. 1, 2, 1886.

1883. *Senftenbergia* Zeiller, *Ann. Sci. Nat.*, 6e sér., vol. xvi, p. 188.
1883. *Senftenbergia* Stur, "Morph. u. Syst. d. Culm-und Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 665.
1885. *Senftenbergia* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 64.
1877. *Senftenbergia* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 193 (299).
1888. *Senftenbergia* Renault, "Cours de botan. foss.," vol. iii, p. 85.
1888. *Senftenbergia* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 50.
1899. *Senftenbergia* Potonié, "Lehrb. d. Pflanzenpalaeont.," p. 100.
1900. *Senftenbergia* Zeiller, "Éléments de Paléobotanique," p. 65.
1902. *Senftenbergia* Potonié in ENGLER and PRANTL, "Die natürlichen Pflanzenfamilien," Teil i, Abth. 4, pp. 371–372.
1920. *Senftenbergia* Scott, "Studies in Fossil Botany," 3rd ed., p. 261.
1921. *Senftenbergia* Gothan, POTONIÉ's "Lehrbuch der Palaeobotanik" (Zweite Auflage), p. 54.

Description.—Fern. Sporangia situated on the lateral veinlets and forming a single row on each side of the median vein, marginal or intra-marginal, oval, slightly pointed at upper end, and with a prominent apical annulus composed of from two to four or five rows of thick-walled cells. Wall of sporangium formed of small thin-walled hexagonal cells. The line of dehiscence is marked by a stomium formed of narrow elongated delicate cells, which extends from the apex to near the base of the sporangium. When lying horizontally on the pinnules the sporangia occupy the whole space between the margin and the median vein, the annulus resting on or touching the midrib of the pinnule. The fertile pinnules are of the same form as the sterile ones and are Pecopteroid in form.

Remarks.—In the genus *Senftenbergia* the annulus forms a prominent apical cap to the sporangium and is composed of several rows of thick-walled cells, which may vary in number from two to five, but the latter number is of rare occurrence. The sporangial wall is formed of thin-walled hexagonal cells which are very seldom preserved, and most usually the prominent apical annulus terminates a structureless oval sporangium (see Pl. CXII, fig. 3*a*). In extreme cases all except the annulus has completely decayed. As pointed out by ZEILLER,* the enlarged figure of the sporangium of *Senftenbergia* given by STUR † only shows the annulus and part of the stomium, the body of the sporangium having entirely disappeared through decay.

TEXT-FIG. 47.—*Senftenbergia elegans* Corda. Sporangium enlarged thirty-eight times. After ZEILLER.

To give a clearer view of the structure of the sporangia than our figures afford, a sporangium of *Senftenbergia elegans* Corda, copied from ZEILLER, is reproduced at text-fig. 47. This shows the apical cap-like annulus, the delicate hexagonal cells of the sporangial wall, and the stomium formed of narrow elongated cells extending from the apex to near the base of the sporangium.‡

* *Ann. Sci. Nat.*, 6e sér., vol. xvi, p. 189. † *Loc. cit.*

‡ Excellent figures of the fructification of *Senftenbergia pennæformis* Brongniart sp. are given by Prof. PAUL BERTRAND in a "Note sur un échantillon fructifié de *Pecopteris pennæformis* du terr. houil. d'Anzin," *Ann. Soc. géol. du Nord*, vol. xli, p. 222, pl. vi, 1912.

Corda recognised the general similarity of the sporangia of *Senftenbergia* with those of the existing Schizæaceæ, and of the genera comprised in this order they approach most closely in structure to those of *Lygodium*. In the Schizæaceæ, however, the annulus is normally formed of a single row of thick-walled cells which surrounds a small central patch or " plate " of small thin-walled cells, and in these respects they differ from the sporangia of *Senftenbergia*. Zeiller, however, found that in *Lygodium Japonicum* Sw., *Lygodium hastatum* Mart., *Lygodium circinatum* Sw., and *Lygodium lanceolatum* Desv., there were some sporangia in which annulus was formed of more than one row of cells. To such cases, the sporangia of *Senftenbergia* have a great resemblance, and even though this resemblance may result from an abnormal development of the annulus in these existing genera, it is not without significance. Zeiller further points out that the apical " plate " on the sporangia of *Lygodium* is sometimes very small, and even if it had been present on the sporangia of *Senftenbergia*, in the fossil state, it would be difficult to observe it.* The probable relationship of the genus *Senftenbergia* to the Schizæaceæ is further strengthened by the occurrence in the Jurassic of the genus *Klukia*, in which " the arrangement of the sporangia, their structure, and the line of dehiscence are as in *Schizaea*, there being only a single series of cells of the annulus." †

The series thus shows a progressive advance as indicated in the following arrangement :—

Senftenbergia⟶*Klukia*⟶*Lygodium*,

and the expressed view that *Senftenbergia* may be the primitive form from which the existing Schizæaceæ have originated ‡ appears to be well founded.

Distribution.—The genus *Senftenbergia* Corda is very rare in Britain, where it has only been recorded from the Westphalian Series.

Senftenbergia ophiodermatica, Göppert sp.

Plate XXX, fig. 3 (*pars*); Plate XCV, figs. 4, 4*a*, 4*b*; Plate XCVI, figs. 1, 1*a*, 1*b*; Plate CXII, figs. 3, 3*a*.

1836. *Asplenites ophiodermaticus* Göppert, " Sys. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, Band xvii, p. 280, pl. xvii, figs. 1, 2.
1850. *Asplenites ophiodermaticus* Unger, " Genera et species Plant. Foss.," p. 139.
1869. *Pecopteris* (*Asplen.*) *ophiodermatica* Schimper, " Traité de paléont. végét.," vol. i, p. 522.
1885. *Senftenbergia* (*Asplenites*) *ophiodermatica* Stur, " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 71.
1885. Cf. *Senftenbergia ophiodermatica* Stur (*pars*), *Ibid.*, p. 87, pl. xlix, figs. 1–4 (*non* pl. l, figs. 2, 3). (*Ref. in part.*)
1886. Cf. *Asplenites divaricatus* Göppert, " Syst. fil. foss." (*loc. cit.*), p. 282, pl. xx, figs. 1, 2.

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* Zeiller, " Observations sur quelques fougères, etc.," *Bull. Soc. botan. de France*, vol. xliv, pp. 214–217.

† Bower, " Origin of a Land Flora," p. 546.

‡ Potonié in Engler and Prantl, " Die nat. Pflanzenfamil.," Teil i, Abt. 2, p. 372; Paul Bertrand, " Note sur un échantillon fructifié de *Pecopteris pennæformis* du terr. houil. d'Anzin," *Ann. Soc. géol. du Nord*, vol. xli, p. 231.

1841. Cf. *Asplenites divaricatus* Göppert, "Gatt. d. foss. Pflanzen," Lief. 3–4, p. 81, pl. xvi, figs. 2, 2*a*.
1869. Cf. *Pecopteris* (*Asplen.*) *divaricata* Schimper, "Traité de paléont. végét.," vol. i, p. 523.
1923. *Dactylotheca ophiodermatica* Kidston, "Foss. Plants Carb. Rocks Gt. Britain" (*Mem. Geol. Surv.*), Explan. to pl. xxx, fig. 3 (*pars*).

Description.—Fern. Fertile frond large, at least tripinnate. Main rachis straight, 0·50 cm. or more in breadth, densely apiculate. Primary pinnæ alternate, springing from main rachis at an open angle or more or less oblique, lanceolate, touching at their margins, rachis straight with fine irregular longitudinal striations and usually a median gutter-like furrow on their upper surface. Secondary pinnæ free, lanceolate, tapering gradually to a blunt point, and the larger bear sixteen or more pairs of pinnules. Pinnules more or less oblong, about 2 mm. to 3 mm. in length and 1·25 mm. to 1·50 mm. in breadth, almost upright or slightly oblique to rachis, sides entire, slightly contracting upwards and terminating in a blunt point. Median vein strong, straight, extending to or dividing into two arms immediately below the apex, lateral veinlets obscured by sporangia. Sporangia oval, slightly tapering to the apex, about 0·50 mm. in length and 0·30–0·35 mm. in breadth, terminating in a prominent apical annulus of 3 or more rows of elongated cells which are much larger than the cells that form the wall of the sporangium. The annulate apex of the sporangium points to the median vein. Sterile condition of plant not known with certainty.

Remarks.—There is some diversity of opinion as to the specific rank or individuality of the various species that have been placed in *Senftenbergia*.

GOTHAN unites *Senftenbergia ophiodermatica* Göppert sp., *Pecopteris æqualis* Brongniart,* *Senftenbergia elegans* Corda,† *Asplenites trachyrrhachis* Göppert, *Asplenites divaricatus* Göppert,‡ and *Cyatheites setosus* Ettingshausen,§ with *Senftenbergia pennæformis* Brongniart sp.|| On the other hand, Professor PAUL BERTRAND is not prepared to accept the union of all these species with *Senftenbergia pennæformis*, nor does he think that all the fertile and sterile specimens figured by ZEILLER ¶ under this name are BRONGNIART's species.**

The genus *Senftenbergia* is very rare in Britain, and I have seen only five fertile specimens, all of which seem to agree perfectly with *Asplenites ophiodermatica* Göppert. No specimens that could be referred to these as their sterile condition have yet been seen. There is no reason to think that they belong to *Senftenbergia* (*Pecopteris*) *pennæformis* Brongniart, as this species has not been found in Britain—at least I have never seen any specimens that could be referred to it. I am therefore inclined to think that the genus *Senftenbergia* may possibly contain a few closely

* "Hist. des végét. foss.," p. 343, pl. cxviii, figs. 1, 2.
† "Flora d. Vorwelt," p. 91, pl. lvii, figs. 1–6.
‡ "Syst. fil. foss.," pp. 281, 282; and pl. xvii, figs. 3, 4; pl. xx, figs. 1, 2.
§ "Steinkohlenfl. v. Radnitz," *Abhandl. k. k. geol. Reichsanst.*, Band ii, Abth. 3, p. 44, pl. xvii, figs. 2, 3.
|| "Hist. des végét. foss.," p. 345, pl. cxviii, figs. 3, 4.
¶ "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 207, pl. xxx, figs. 1–4.
** BERTRAND, "Note sur un échantillon fructifié de *Pecopteris pennæformis*, etc.," *Ann. Soc. géol. du Nord*, vol. xli, p. 222, 1912.

related species which we are unable to separate specifically on account of our imperfect knowledge of the group.

In regard to the specimens referred to *Senftenbergia ophiodermatica* by STUR,* those given on his second plate (pl. l) have been shown to belong to *Senftenbergia pennæformis*.† Of the four specimens given on his pl. xlix, figs. 2, 3, and 4 are fertile, but the sporangia seem to have been imperfectly preserved, and their structure is not described. It is therefore impossible to determine definitely the generic position of these specimens—whether belonging to *Dactylotheca* or *Senftenbergia*. The sterile specimen given at fig. 1 has a great similarity in the form of the pinnæ and pinnules to the type of *Asplenites ophiodermaticus* Göppert, and, if correctly identified, is the only figured specimen of the sterile condition of GÖPPERT's plant.

As all our specimens seem to agree well with GÖPPERT's *Asplenites ophiodermatica*, I refer them all to that species, but place them in *Senftenbergia* on account of their bearing the sporangia of that genus. The relationship of this species to *Senftenbergia pennæformis* Brongniart sp. must be left an open question for the present.

On the slab shown on Pl. XXX, fig. 3, of this Memoir, parts of two primary pinnæ of *Senftenbergia ophiodermatica* occur along with fragments of *Sphenopteris Walteri*. The secondary pinnæ of this example are of similar size and form to those seen on GÖPPERT's type-figure. The pinnules also agree. They are oblong, with straight sides, slightly contracted upwards, have rounded apices, and attached by the whole width of their base to the rachis. They are free or only united to each other very slightly at their bases. All the pinnules are fertile. The larger pinnules usually bear 8 to 10 sporangia, frequently placed close to each other, and cover the under surface of the pinnule. On some of the sporangia the apical annulus can be seen. Whatever may be the relationship of *Senftenbergia ophiodermatica* Göppert sp. to *Senftenbergia pennæformis* Brongniart sp., I think there can be no doubt that this specimen belongs to GÖPPERT's species.

Another fertile example is given at fig. 4, Pl. XCV. A small part of the punctated main rachis is seen towards the top of the specimen, but is not visible on the figure. The secondary pinnæ are free, taper gradually to the apex, and are fertile throughout their whole length. They end in a narrow, sub-triangular blunt-pointed pinnule. The larger pinnules are about 3 mm. in length and 1·25 mm. to 1·50 mm. in breadth, and may bear as many as sixteen sporangia, sometimes touching each other laterally, and sometimes free from one another. They are situated in two rows, one row on each side of the straight median vein. A part of this specimen is enlarged two times at fig. 4*a* to show the form of the pinnules, and a single pinnule is enlarged seven and a half times at fig. 4*b* to exhibit the arrangement of the sporangia, which possess the typical annulus of *Senftenbergia*.

A third specimen is seen on Pl. XCVI, fig. 1. It is very similar to that last described, but on this small example the sporangia show the annulus more perfectly.

* "Carbon-Flora d. Schatzlarer Schichten," p. 87, pl. xlix, figs. 1–4; pl. l, figs. 2, 3.

† BERTRAND, *Ann. Soc. géol. du Nord*, vol. xli, p. 229.

At figs. 1a and 1b of the same plate two pinnules are enlarged eight times to show their form, and the arrangement of the sporangia. The apical annulus in all cases occurs at the end which lies next the median vein. In none of these fertile specimens are the lateral veinlets visible, the mode of attachment of the sporangia to them cannot therefore be observed. They seem to be parallel with and attached along the lateral veinlets. Some sporangia from this specimen are enlarged about twelve times at fig. 3, Pl. CXII. They lie very close together, and some have apparently undergone displacement. Two of them more highly enlarged are given at fig. 3a to show the apical annulus. The bodies of the sporangia are seen at a, a, with their apical annulus at b, b, the cells of which are much larger than those of the sporangia wall, which are not well seen on our specimens.

For the specimens from Yorkshire I am indebted to Mr W. Hemingway, and for that from South Staffordshire to Mr H. Insley.

Distribution.—Senftenbergia ophiodermatica Göppert is very rare, and has been found only in the Westphalian Series.

WESTPHALIAN SERIES.

South Staffordshire Coalfield.

Horizon: Blue Measures, 6 feet above Brooch Coal. *Locality:* Hamstead Colliery, Great Barr, 2½ miles south-east of Walsall (H. Insley).

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley (W. Hemingway).

"Pecopteris Brongniart."

1822. *Filicites* (*Pecopteris*) Brongniart, "Classif. des végét. foss.," *Mém. Mus. d'Hist. nat.*, vol. viii, p. 33.
1826. *Pecopteris* Sternberg, "Essai flore monde prim.," vol. i, fasc. iv, p. xvii.
1828. *Pecopteris* Brongniart, "Prodrome," p. 54.
1831. *Pecopteris* Brongniart, "Hist. des végét. foss.," p. 267.
1849. *Pecopteris* Brongniart, "Tableau des genres de végét. foss.," *Dict. univ. d'Hist. nat.*, p. 24.
1869. *Pecopteris* Schimper, "Traité de paléont. végét.," vol. i, pp. 369 and 498.
1900. *Pecopteris* Zeiller, "Éléments de paléobot.," p. 87.
1910. *Pecopteris* Seward, "Fossil Plants," vol. ii, p. 576.
1921. *Pecopteris* Gothan in Potonié's "Lehrb. d. Paläobot.," p. 92.

Remarks.—The form-genus *Pecopteris* as originally employed by Brongniart included an assemblage of plants, of which some are probably ferns, but many are undoubtedly referable to the Pteridospermeæ. In his Memoir of 1822, p. 33 (quoted above), he defined *Pecopteris* as embracing the species of which the frond is pinnatifid, with pinnules adhering by their base to the rachis, traversed by a median nerve with secondary pinnatic nerves.

STERNBERG, in 1826 (*op. cit.*, p. xxi), founded his genus *Alethopteris* in which were placed several species included by BRONGNIART in *Pecopteris*, but this genus was not adopted by BRONGNIART in his "Prodrome," published in 1828, where he thus defines the characters of *Pecopteris*: frond one, two, or three times pinnate; pinnules adhering by their base to the rachis, or rarely free, traversed by a median nerve, which extends almost to the extremity of the pinnule; secondary nerves departing almost perpendicularly to the median nerve, simple or one or two times dichotomized.

In 1836 GÖPPERT * created his genus *Asterocarpus* for a fertile Pecopteroid plant, but as this generic name had been previously employed, PRESL † altered it to *Asterotheca*. In the same year, ZENKER described the genus *Scolecopteris* for a fructification similar in type to that of *Pecopteris polymorpha* Brongniart. These all reduced the number of the then known species referable to *Pecopteris*.‡ On the adoption of these genera by BRONGNIART, he modifies and more clearly defines the characters of the genus *Pecopteris* in his "Tableau des genres de végétaux fossiles," published in 1849, where he describes the frond as bi-tripinnate, the pinnæ elongate, pinnatifid, with pinnules adhering by the base to the rachis and often amongst themselves to a greater or less extent, not decurrent, contiguous or almost contiguous. All the secondary nerves spring from the median nerve of the pinnule, and are simple, bifurcate, or rarely trifurcate.

Fertile specimens of another of the plants included in *Pecopteris* were described by WEISS,§ who instituted the genus *Ptychopteris* for its reception.

In addition to the species removed from *Pecopteris* on account of the discovery of their fructification, and those included in *Alethopteris* Sternberg, there are others which, though only known in a sterile condition, possess such distinctive characters that generic position has been accorded them. One of the most important of these is *Mariopteris*.||

Most botanists in dealing with these plants, even when they recognise the importance of the genera founded on their fructification, still use the generic name *Pecopteris* in conjunction with the name of the genus founded on characters derived from the fructification, in brackets thus: "*Pecopteris* (*Asterotheca*) *crenata* Brongniart." Here, however, I adopt those genera which have been founded on characters derived from the fructification, and free such species from all association with the form-genus *Pecopteris* Brongniart.

For those species in which the fructification is unknown, but which possess pinnules that have the same general form and type of nervation as the plants included in *Asterotheca* Presl, *Scolecopteris* Zenker, and *Ptychocarpus* Weiss, it is

* "Syst. fil. foss.," p. 188.

† PRESL in CORDA, "Flora d. Vorwelt," p. 59, 1845.

‡ Other genera such as *Dactylotheca* Zeiller and *Senftenbergia* Corda have been also founded on plants originally placed in *Pecopteris*.

§ "Foss. Flora d. jüngst. Stk. u. Rothl.," p. 94, 1869.

|| *Mariopteris* Zeiller, "Végét. foss. terr. houil.," *Expl. carte géol. France*, vol. iv, p. 68, 1878. Another issue, 1880.

proposed to raise to generic rank the group name *Eupecopteris*, employed by Gothan to indicate this group of Pecopterids.*

For the other species, which do not fall into the genera mentioned above, Brongniart's genus *Pecopteris* is retained.

Some such course is absolutely necessary to enable a separation to be made of the two distinct groups that occur amongst those species still known in the sterile condition only. Those placed in the genus *Eupecopteris* usually occur in the higher horizons in the Carboniferous sequence, though some included in *Pecopteris*, as employed here, occur in a similar geological horizon. When the question is considered from the point of distribution of the species, however, it is most desirable to have some means of distinguishing, when recording the occurrence of a species, whether it belongs to the *Pecopteris* group or *Eupecopteris* group. I have the less hesitation in adopting this course, as the type of *Pecopteris* Brongniart was *Pecopteris pennæformis* (now *Senftenbergia pennæformis*), which, were its fructification unknown, would find a place in *Eupecopteris*.

The following genera are therefore adopted here for species which have been more or less usually included in *Pecopteris* :—

Asterotheca Presl.
Scolecopteris Zenker.
Ptychocarpus Weiss.
Eupecopteris (Gothan) Kidston.
Pecopteris Brongniart (*pars*).

Genus **Asterotheca** Presl.

1836. *Asterocarpus* Göppert (*non* Necker, *non* Ecklon and Zenker), " Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 188.
1850. *Asterocarpus* Unger, " Genera et Species Plant. Foss.," p. 206.
1869. *Asterocarpus* Schimper, " Traité de Paléont. végét.," vol. i, p. 508 ; vol. iii, p. 583.
1869. *Asterocarpus* Weiss, " Foss. Flora d. jüngst. Stk. u. Rothl.," p. 90.
1845. *Asterotheca* Presl in Corda, " Flora d. Vorwelt," p. 89.
1879. *Asterotheca* Schimper in Zittel, " Handb. d. Palaeont.," Abth. 2, " Palaeophytologie," p. 89.
1888. *Asterotheca* Zeiller, " Flore foss. bassin houil. de Valenciennes," p. 36.
1888. *Asterotheca* Zeiller, " Flore foss. terr. houil. de Commentry," p. 97 (*Bull. Soc. Ind. min.*, ser. 3, vol. ii, livr. 2).
1900. *Asterotheca* Zeiller, " Éléments de paléobot.," p. 59.
1910. *Asterotheca* Seward, " Fossil Plants," p. 398.
1921. *Asterotheca* Gothan in Potonié, " Lehrb. d. Paläobotanik " (Zweite Auflage), p. 63.
1845. Cf. *Hawlea* Corda, *op. cit.*, p. 89.
1888. *Hawlea* Stur (*pars*), " Zur Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 49.

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* Gothan in Potonié's " Lehrb. d. Paläobotanik " (Zweite Auflage), p. 92, 1921.

1885. *Hawlea* Stur (*pars*), "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 106.
1883. *Grand'Eurya* Stur (*non* Zeiller), "Morph. u. Syst. d. Culm-u. Carbonfarne," (*loc. cit.*), p. 45.
1883. *Scolecopteris* Stur (*pars*), *ibid.*, p. 88.

Description.—Fertile and sterile pinnules similar, or the limb of the former slightly reduced. Sporangia exannulate, ovoid, pointed or obtusely pointed at the apex, united to the number of four or five (rarely more or less) around a very slightly elevated receptacle, each group thus forming a sessile synangium normally erect on the surface of the limb. Sterile pinnules oblong, with rounded or blunt apices, attached by the whole width of their base or slightly contracted below, free or more or less united to each other, entire. A single vein enters each pinnule, and gives rise to the simple, bifid or trifid lateral veins.

Remarks.—The fronds of *Asterotheca* attained to great size. The sporangia are attached to a very slightly elevated receptacle situated on the lateral veins. Sometimes the synangia hold a central position between the midvein and the margin, or they may be placed nearer to the midrib, while occasionally they are situated close to the margin of the pinnule. The sporangia are attached around the receptacle and also slightly to each other by their bases, but are free for the greater part of their length. They thus form a small star-shaped synangium.

The sporangia forming the groups are usually of equal size, but if the synangia are placed near to the median vein, those next to it are sometimes shorter than those on the opposite side.

In the immature condition the sporangia stand upright, but at maturity they appear to bend outwards and lie horizontally on the surface of the pinnule. These features are seen at text-fig. 48. A shows two fertile pinnules enlarged two times. At B a synangium is seen from above, enlarged about six times, and C shows a longitudinal section of a pinnule passing through three synangia. The star-like arrangement of the sporangia is also well seen on Pl. CXX, figs. 2*a* and 5. There does not seem to be any special contrivance for the opening of the sporangia, which dehisce by a longitudinal cleft that passes down the ventral surface.

TEXT-FIG. 48.—*Asterotheca Miltoni* Artis sp. Fertile pinnules and synangia. (After ZEILLER.)

As a rule the synangia are placed in a single row on each side of the midrib, but occasionally the smaller fertile pinnules are united to each other for the greater part of their length when the pinnæ assume the form of elongated crenate pinnules with two or more rows of synangia on each side of the (pinna) rachis.

Asterotheca Presl differs from *Scolecopteris* Zenker in that the receptacle to which the sporangia are attached forms only a small mammillate point, whereas in *Scolecopteris* it forms a short column or stalk, to which the sporangia are also united to a much greater extent.

The fronds of *Asterotheca* are supposed to have been borne on the stems known as *Caulopteris* (*Psaronius*), and the genus has usually been classed with the Marattiaceæ.

The evidence available for arriving at a decision as to the systematic position of *Asterotheca* perhaps favours its being regarded as containing Marattiaceous Ferns, but I do not think the evidence is conclusive. I prefer therefore to leave the systematic position of *Asterotheca* an open question.

The generic differences which separate *Scolecopteris* from *Asterotheca* are those of degree rather than of structure. The former genus I believe to be more probably a Pteridosperm than a fern, but this point will be dealt with more fully when describing *Scolecopteris*.*

Distribution.—The genus *Asterotheca* has been recorded from the Westphalian, Staffordian, and Radstockian Series. The members of the genus gradually increase in frequency from the Westphalian Series upwards and reach their maximum development in the Radstockian, where it is most characteristic. The genus extends also into the Permian.

Asterotheca arborescens Schlotheim sp.

Plate CXIV, fig. 1.

1804. Schlotheim, "Flora d. Vorwelt," p. 41, pl. viii, fig. 13.
1820. *Filicites arborescens* Schlotheim, "Petrefactenkunde," p. 404.
1832. *Filicites arborescens* Schlotheim, "Verstein. aus v. SCHLOTHEIM'S Sammlung. Kupfertafeln," p. 7, pl. viii, fig. 13.
1826. *Pecopteris arborea* Sternberg, "Essai flore monde prim.," vol. i, fasc. iv, p. xviii.
1828. *Pecopteris arborescens* Brongniart, "Prodrome," p. 56.
1833. *Pecopteris arborescens* Brongniart, "Hist. des végét. foss.," vol. i, p. 310, pl. cii, figs. 1–2; pl. ciii, figs. 2–3.
1838. *Pecopteris arborescens* Sternberg (*pars*), "Essai flore monde prin.," vol. ii, fasc. vii–viii, p. 147.
1848. *Pecopteris arborescens* Gutbier, "Verstein. d. Rothl. in Sachsen," p. 16, pl. ii, fig. 9.
1851. *Pecopteris arborescens* Germar, "Verstein. v. Wettin u. Löbejün," p. 97, pl. xxxiv, figs. 1–3; pl. xxxv, figs. 5–7 (*non* fig. 4).
1865. *Pecopteris arborescens* Heer, "Urwelt d. Schweiz," p. 13, pl. i, fig. 8.
1876. *Pecopteris arborescens* Roemer, "Lethæa Geogn.," vol. i, p. 176, pl. lviii, fig. 3 (pl. lii, fig. 4 ?).
1877. *Pecopteris arborescens* Grand'Eury, "Flore carb. du Départ. de la Loire," p. 68, pl. viii, fig. 6.
1879. *Pecopteris arborescens* Schimper in ZITTEL, "Handb. d. Palaeont.," Abth. 2, "Palaeophytologie," p. 127, fig. 103.
1879. *Pecopteris arborescens* Lesquereux, "Coal Flora," vol. i, p. 230 (pl. xli, figs. 6–7 ?) (*ref. in part*).
1880. *Pecopteris arborescens* Zeiller, "Végét. foss. du terr. houil.," p. 81, pl. clxix, fig. 4. (*Expl. Carte géol. France*, vol. iv.)
1883. *Pecopteris arborescens* Renault, "Cours de botan. foss.," vol. iii, p. 108, pl. xvii, figs. 1–3.
1888. *Pecopteris* (*Asterotheca*) *arborescens* Zeiller, "Flore foss. bassin houil. de Commentry," *Bull. Soc. Ind. min.*, ser. 3, vol. ii, p. 111, pl. xi, figs. 1–2.
1890. *Pecopteris arborescens* Grand'Eury, "Géol. et paléont. du bassin houil. du Gard," p. 274, fig. D, d.
1890. *Pecopteris* (*Asterotheca*) *arborescens* Zeiller, "Flore foss. bassin houil. et perm. d'Autun et d'Épinac," *Études Gîtes Min. France*, fasc. 2, pt. 1, p. 43, pl. viii, fig. 1.

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* See SCOTT, "Studies in Fossil Botany," 3rd ed., pt. 1, pp. 262–263, 1920.

1893. *Pecopteris* (*Scolecopteris*) *arborescens* Sterzel, "Flora d. Rothl. im Plauen. Grunde bei Dresden," *Abhandl. Math.-Phys. Kl. k. Sächs. Gesellsch. d. Wissensch.*, Band xix, p. 17, pl. i, figs. 16–17.
1893. *Pecopteris arborescens* Potonié (*pars*), "Flora d. Rothl. Thüringen," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft 9, Theil 2, p. 57, pl. vi, fig. 6 (fig. 7 ? *non* fig. 5).
1899. *Pecopteris* cf. *arborescens* White (*pars*), "Foss. Flora Coal Meas. of Missouri," p. 78, pl. xliv, fig. 3 ?
1901. *Pecopteris arborescens* Kidston, *Proc. Yorks. Geol. and Polytech. Soc.*, vol. xiv, pt. ii, pp. 194, 209, pl. xxvii, fig. 3.
1903. *Pecopteris arborescens* Fritel, "Hist. nat. de la France," 24 *bis* part, "Paléobotanique : Plantes fossiles," p. 46, pl. ix, figs. 2, 3.
1908. *Pecopteris arborescens* Yokoyama, "Palæozoic Plants from China," *Journ. Coll. Sci. Imp. Univ. Tōkyō*, vol. xxiii, article 8, p. 14, pl. iv, fig. 4.
1908. *Pecopteris arborescens* Gibson, "Geology of Coal and Coal Mining," pl. i.
1920. *Pecopteris arborescens* Gibson, "Coal in Great Britain," etc., pl. ii.
1836. *Cyatheites arborescens* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 321.
1845. *Cyatheites arborescens* Unger, "Synop. plant. foss.," p. 87.
1873. *Cyatheites arborescens* Feistmantel, *Zeitschr. deutsch. geol. Gesellsch.*, Band xxv, p. 600, pl. xviii, figs. 15, 15*a*.
1876. *Cyatheites arborescens* Feistmantel, "Verstein. d. böhm. Ablager.," Abth. 3, p. 70, pl. xviii, figs. 6, 6*a*.
1876. *Cyatheites arborescens* Heer, "Foss. Flora Helv.," p. 27, pl. viii, figs. 1–4.
1883. *Cyatheites arborescens* Schenk in RICHTHOFEN'S "China," vol. iv, p. 212 and p. 229, pl. xlv, figs. 13–16.
1869. *Cyathocarpus arborescens* Weiss, "Foss. Flora d. jüngst. Stk. u. Rothl.," p. 84.
1901. *Cyathocarpus arborescens* Stefani, "Flore Carb. e Perm. della Toscana" (*Ist. Studi sup. prat. e di Perfezionamento, Firenze*), p. 14, pl. v, fig. 4.
1877. *Asterotheca arborescens* Stur, "Culm Flora," Heft 2, p. 293.
1914. *Asterotheca arborescens* Bureau, "Bassin de la Basse Loire," fasc. 2, "Flores fossiles," *Études Gîtes Min. France*, p. 70, pl. liv, figs. 2, 2A (? fig. 1).
1883. *Scolecopteris arborescens* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 754 (122), text-fig. 20*a* ; p. 734 (102).
1885. *Scolecopteris arborescens* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, p. 196, text-fig. 24*a*.
1861. *Cyatheites Schlotheimii* Göppert (*pars*), "Foss. Flora d. perm. Form.," p. 120, pl. xv, fig. 1.

Description.—Frond very large, tripinnate. Rachis attaining a width of 3 cm., smooth or bearing slightly-vertical elongated apiculi. Primary pinnæ alternate, free or (more generally) slightly overlapping at their margins, linear-lanceolate, slightly narrowed at the base and suddenly contracted at the apex into a point ; somewhat ascending ; rachis smooth or finely punctate, attaining a width of rather more than 1 cm. Secondary pinnæ 2 cm. to 11 cm. in length, very slightly ascending, alternate, free, or touching at their margins, linear or linear-lanceolate, of almost equal width for the greater part of their length, and contracted at apex into a blunt point ; rachis straight, stout.

The secondary pinnæ become simply lobed near the top, and at the extreme apex are represented by more or less elongated pinnules, in which the veins may be dichotomously divided.

Pinnules alternate, arising at right angles to the rachis or very slightly oblique to it, short, more or less longer than broad, sides straight, almost rectangular in form with blunt rounded apices, free though touching laterally, but not overlapping, slightly convex, surface generally smooth, but occasionally villous and united to the rachis by the whole width of their base.

Median vein straight, extending to the apex and giving off simple lateral veinlets which run to the margin of the pinnule with a gently ascending course.

Fertile pinnæ and pinnules similar in form to the sterile ones. Fructification formed of four, more rarely three or five, oval sporangia which are united to each other at their base and form little star-like synangia measuring about 0·75 mm. in diameter, placed on the lateral veins and forming a single row on each side of the midrib of the pinnule. The synangia cover all the lower surface of the pinnule except at its apex.

Remarks.—The fragmentary specimens of *Pecopteris arborescens* Schlotheim sp. usually found give little idea of the size and beauty which must have been possessed by this species. The most perfect example I have met with is the part of a primary pinna given natural size at fig. 1, Pl. CXIV, whose full length is 29 cm., but it is imperfect at both ends, and represents only a small fragment of a frond.

Germar * figures a portion of the main rachis of a frond 3 cm. in width, which gives off primary pinnæ whose rachises are over 1 cm. in thickness at the base. This gives some idea of the great size to which the fronds of *Asterotheca arborescens* attained.

So far as one can judge at present, the frond was tripinnate, though possibly some of the lower primary pinnæ may have been tripinnate, and the frond in this region might have been quadripinnate.

The ultimate pinnæ are of almost equal width for the greater part of their length, and as the pinnules are of equal or almost equal length, the pinnæ have straight, crenulate margins. The pinnæ are placed very close to each other and their margins frequently touch those of the neighbouring pinnæ, but they do not overlap. Towards their apex they contract somewhat suddenly, and end in a blunt point.

The short oblong blunt-pointed pinnules are also closely placed on the rachis, their margins touching, but they are quite free from any lateral union. The median vein is strong and extends to the summit of the pinnule, giving off opposite or sub-opposite simple veinlets, which, with a slight upward but straight course, extend to the margin of the pinnule.

The uppermost secondary pinnæ gradually assume the form of crenate, and then simple, elongated pinnules in which the vein may divide into two arms, but these pinnule-like pinnæ are formed by the union of a number of individual pinnules, and must be regarded as modified pinnæ.

The fertile pinnules do not differ in form from those of the sterile condition. The synangia are formed of 3–5 sporangia, usually only four, arranged around a common point and united to each other by their bases. They form little blunt-pointed stars. Each of the lateral veins bears a single synangium, which occupies

* Germar, *loc. cit.*, pl. xxxiv, fig. 1.

nearly the whole of the limb lying between the median vein and the margin of the pinnule.

Fertile specimens do not appear to be very uncommon, but any that have come under my own observation were in an immature condition.

Fertile pinnæ and synangia of *Asterotheca arborescens* have, however, been figured by GRAND'EURY.*

The upper secondary pinnæ of the fertile primary pinnæ are usually (or always) sterile, and on the fertile secondary pinnæ a few of the basal pinnules as well as the apical portion of the pinna are also sterile.

The nearest ally to *Asterotheca arborescens* Schlotheim sp. is *Asterotheca cyathea* Schlotheim sp., but in the latter the pinnæ gradually begin to narrow about the upper third of their length and terminate in sharper points, the pinnules are of very unequal length on the same pinna, some being markedly less than others; and they gradually narrow from their base upwards where they terminate in a blunt point. The lateral veinlets in *Asterotheca arborescens* seem to be always undivided, but in *Asterotheca cyathea*, though some of the pinnules have a similar nervation to that of *Asterotheca arborescens* (Pl. CXIV, fig. 2*b*), one usually finds many of the pinnules with once-divided veinlets along with the single ones (Pl. CXVI, fig. 2*b*, and text-fig. 49). The unequal length of the pinnules on *Asterotheca cyathea* also gives an uneven outline to the margins of the pinnæ (Pl. CXVI, figs. 3, 3*a*) in contrast to the equal-sized pinnules and straight outline of the margin of the pinnæ of *Asterotheca arborescens*. These differences readily distinguish the two species.

From *Eupecopteris Camertonensis* Kidston n. sp.,† *Asterotheca arborescens* is distinguished by the form of its pinnules. These in *Eupecopteris Camertonensis* are convex, united to each other at their bases, narrow gradually upwards, and terminate in obtuse apices. The median vein dichotomizes and ends in a fork, and the steeply-ascending lateral veinlets also divide into two arms.

From the references to *Asterotheca arborescens*, I have excluded the figure given by GERMAR on his pl. xxxv, fig. 4, because the dichotomous nervation shown in the enlargement of the pinnules given at fig. 4*a* is altogether dissimilar to the nervation of *Asterotheca arborescens*. This specimen I think should be referred to *Asterotheca Candolleana* Brongniart sp.

Distribution.—*Asterotheca arborescens* Schlotheim sp. has been recorded from all the groups of the Radstockian Series and from the Newcastle-under-Lyme Group of the Staffordian Series. It is perhaps more common than the records of its occurrence would lead one to believe, for in the horizons in which it has been collected specimens belonging to the *Pecopteris-Asterotheca* Section are fairly frequent, and though the form of their pinnules is generally well shown, the nervation has in many cases entirely disappeared. In this condition it is impossible to identify satisfactorily the species to which such specimens belong.

* "Flore Carb. du Départ. de la Loire, etc.," *Mem. Acad. Sci., Paris*, xxiv, No. 1, pl. viii, figs. 6A and 6B.

† See Pl. CXV, figs. 2, 2*a*; to be described fully in Part 6 of this Memoir.

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon : ?. *Localities :* Radstock, Somerset; Braysdown Colliery, near Radstock, Somerset; Wellsway Pit, near Radstock, Somerset; Lower Conygre Pit, Timsbury, $2\frac{1}{2}$ miles N.N.W. of Radstock, Somerset; Camerton, 2 miles north of Radstock, Somerset.

Somerset and Bristol Coalfield.

FARRINGTON GROUP.

Horizon : ?. *Locality :* Old Mills Pit, Farrington Gurney, $7\frac{1}{2}$ miles north of Shepton Mallet, Somerset.

South Wales Coalfield.

FARRINGTON GROUP.

Horizon : Four-foot Seam of Swansea. *Locality :* Gladys Colliery, 1 mile E.S.E. of Penller-gare Church, Glamorganshire (Collection of Geological Survey, London).

Horizon : No. 1 Llantwit Seam. *Locality :* Beddau, near Llantrisant, Glamorganshire (D. Davies).

Ayrshire Coalfield.

KEELE GROUP.

Horizon : "Red beds." *Locality :* Barrony Pit, Oldbyres Farm, $1\frac{1}{2}$ miles west of Auchinleck.

South Staffordshire Coalfield.

KEELE GROUP.

Horizon : ?. *Localities :* Hamstead Colliery, Great Barr, $2\frac{1}{2}$ miles south-east of Walsall; Boring at Langley Green, 3 miles south-east of Dudley.

STAFFORDIAN SERIES.

Forest of Wyre Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon : At depth of 1275 feet. *Locality :* Claverley Boring, 5 miles east of Bridgnorth, Shropshire.

Shrewsbury Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon : ?. *Localities :* Old Shaft south of Broxton Wood, 400 yards E.S.E. of Westbury Village (Collection of Geological Survey, London); Bausley; Old Shaft 250 yards south-west of road at Coedwaybank.

Somerset and Bristol Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: ?. *Localities:* Parkfield Colliery, Pucklechurch, Gloucestershire; Coal Pit Heath, near Bristol, Gloucestershire (Mrs Barclay); Round Oak Colliery, Pensford, 2 miles north of Clutton, Somerset (R. Crookall).

Asterotheca cyathea Schlotheim sp.

Plate CXIV, figs. 2, 2*a*, 2*b*, 3; Plate CXV, figs. 1, 1*a*, 1*b*; Plate CXVI, figs. 3, 3*a*, 3*b*, 4; Plate CXVII, figs. 3, 3*a*; text-fig. 49.

1804. Schlotheim, "Flora d. Vorwelt," p. 38, pl. vii, fig. 11.
1820. *Filicites cyatheus* Schlotheim, "Petrefactenkunde," p. 403.
1828. *Pecopteris cyathea* Brongniart, "Prodrome," p. 56.
1832. *Filicites cyatheus* Schlotheim, "Verstein. aus v. Schlotheim's Sammlung. Kupfertafeln," p. 6, pl. vii, fig. 11.
1833. *Pecopteris cyathea* Brongniart, "Hist. des végét. foss.," vol. i, p. 307, pl. ci, figs. 1–3 (? fig. 4).
1838. *Pecopteris cyathea* Sternberg, "Versuch," ii, fasc. vii–viii, p. 149.
1872. *Pecopteris cyathea* Heer, "Monde prim. de la Suisse," p. 14, pl. i, fig. 7.
1877. *Pecopteris cyathea* Grand'Eury, "Flore Carbon. du Départ. de la Loire," p. 68, pl. viii, fig. 7.
1880. *Pecopteris cyathea* Zeiller, "Végét. foss. du terr. houil.," *Expl. Carte géol. de la France*, vol. iv, p. 81, pl. clxix, figs. 5, 6.
1883. *Pecopteris cyathea* Renault, "Cours de botan. foss.," vol. iii, p. 91, pl. xvii, figs. 4, 5.
1888. *Pecopteris (Asterotheca) cyathea* Zeiller, "Flore foss. terr. houil. de Commentry," *Bull. Soc. Ind. min.*, ser. 3, vol. ii, livr. 2, p. 119, pl. xiii, figs. 1–4.
1890. *Pecopteris (Asterotheca) cyathea* Zeiller, "Flore foss. bassin houil. et perm. d'Autun et d'Épinac," pt. 1, *Études Gîtes Min. France*, p. 45, pl. viii, figs. 2–4.
1903. *Pecopteris cyathea* Fritel, "Hist. nat. de la France," 24e bis, "Paléobotanique: Plantes fossiles," p. 46, pl. ix, fig. 1.
1905. *Pecopteris (Asterotheca) cyathea* Zalessky, "Obercarb. Flora d. Steinkohl. von Jantai," *Verhandl. russ. k. Min. Gesellsch.*, ser. 2, vol. xlii, p. 391, fig. 5.
1877. *Asterotheca cyathea* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 187.
1879. *Asterotheca cyathea* Schimper in Zittel, "Handb. d. Palaeont.," Abth. 2, "Palaeophytologie," p. 90, fig. 65 (3–5).
1883. *Scolecopteris cyathea* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Abth. 1, Band lxxxviii, p. 122, text-fig. 25, p. 118.
1885. *Scolecopteris cyathea* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Abth. 1, Band xi, p. 754 (204), text-fig. 29, p. 202.
1880. *Pecopteris arborescens* var. *cyathea* Rothpletz (*pars*), "Steinkohlform. u. d. Flora Ostseite Todi," *Abhandl. Schweiz. paläont. Gesellsch.*, Band vi, p. 7, pl. ii, fig. 5.
1826. *Pecopteris Schlotheimii* Sternberg, "Essai flore monde prim.," vol. i, fasc. iv, p. xviii.
1836. *Cyatheites Schlotheimii* Göppert, "Syst. fil. foss.," *Nova Acta Akad. Leop.-Carol.*, xvii, p. 320.
1845. *Cyatheites Schlotheimii* Unger, "Synop. plant. foss.," p. 86.
1838. *Steffensia cyatheoides* Presl in Sternberg, "Versuch," vol. ii, fasc. vii–viii, p. 122.
1855. *Cyatheites arborescens* Geinitz (*non* Schlotheim) (*pars*), "Verstein. d. Steinkf. in Sachsen," p. 24, pl. xxviii, figs. 7–11.
1869. *Pecopteris arborescens* Schimper (*pars*), "Traité de paléont. végét.," vol. i, p. 499.
1899. *Pecopteris arborescens* Hofmann and Ryba (*non* Schlotheim), "Leitpflanzen," p. 50, pl. vi, figs. 6–7 (8 ?).

1899. ? *Pecopteris* cf. *arborescens* White (*pars*), "Fossil Flora Lower Coal Measures Missouri," *Mon. U.S. Geol. Surv.*, xxxvii, p. 78, pl. xxxiii, fig. 7; pl. xxxvi, fig. 3; pl. xlvii, fig. 6.
1907. *Pecopteris* (*Asterotheca*) *arborescens* Sterzel (*non* Schlotheim), "Karbon u. Rothl. im Grossherzog. Baden," *Mitt. Badisch. Geol. Landesanst.*, Band v, Heft 2, p. 537, pl. xxxvi, fig. 2.
1912. Cf. *Pecopteris arborescens* Arber, "Foss. Flora Forest of Dean Coalfield," *Phil. Trans. Roy. Soc.*, ser. B, vol. ccii, p. 249, pl. xi, fig. 3.
1901. *Cyathocarpus Pillæ* Stefani, "Flore Carb. e. Perm. della Toscano," p. 19, pl. viii, fig. 1.
1914. *Asterotheca cyathea* Bureau, "Bassin de la Basse Loire," fasc. ii, "Flores fossiles," *Études Gîtes Min. France*, p. 74 (? pl. xxvii, fig. 7).

Description.—Frond very large, tripinnate, main rachis attaining a width of 4 cm. or more, smooth or marked with faint irregular longitudinal striæ. Primary pinnæ alternate, from 30 cm. to 60 cm. or more in length and from 8 cm. to 20 cm. in width, spreading outwards or somewhat ascending, their margins touching or slightly overlapping, narrow, ovate-lanceolate, slightly contracted at the base, with an equal width for about three-quarters or four-fifths of their length, then rapidly contracting into a somewhat blunt point. Secondary pinnæ alternate, 10 cm. or more in length and 15 mm. in width, slightly ascending or spreading straight outwards, free or margins touching or overlapping, linear-lanceolate, with an obtusely pointed apex.

Pinnules alternate, attached by their whole base, though sometimes a slight basal contraction can be observed, contiguous, free or united to each other at their base, oblong, usually from twice to three times and a half as long as broad and frequently irregular in size. The under surface of the fertile pinnules shows a fine villose covering.

Nervation consists of a straight median vein which extends to the apex of the pinnule or may terminate in a dichotomy; lateral veinlets slightly ascending, simple or once divided at their base, or a little distance above it.

Fertile pinnules similar in form to the sterile ones. Sporangia ovoid, sharp at the summit, upright, 1 mm. in length and 0·25 to 0·33 mm. in breadth, united at their bases, touching each other laterally, converging towards the centre and forming synangia of 4 (more rarely 3 or 5) sporangia. The synangia when formed of four sporangia are almost square in outline, are borne on the lateral veinlets about halfway between the midrib and the margin, and occupy the whole of the limb of the pinnule. They thus form two rows, one on each side of the midrib.

Remarks.—Of *Pecopteris cyathea* Schlotheim sp. I have seen only fragmentary examples of primary pinnæ, which give no idea of the large size of its fronds. Some of these specimens are shown on Pls. CXIV, CXV, and CXVI. Large examples, however, have been examined by Zeiller, and on his description the general account of the form of the frond given here is based.

Part of a primary pinna, of which the complete specimen is 30 cm. in length but which does not show the base, is given on Pl. CXV, fig. 1. The rachis is buried in the matrix. The secondary lanceolate pinnæ are free, but placed close together.

They are not contracted at base, are of almost equal width for about three-quarters of their length, then gradually contract and terminate in a blunt point. This example shows very well the irregularity in the length of the pinnules, which gives a slightly ragged outline to the pinnæ. The part of a pinna enlarged three times at fig. 1*a* illustrates this feature. At fig. 1*b* a pinnule is enlarged seven times to show the nervation. In this example the midvein extends to the apex without dividing into two forks. This figure also shows the gradual contraction of the pinnule in width from below upwards.

An upper part of a primary pinna is given natural size on Pl. CXIV, fig. 2, and its apical portion is enlarged three times at fig. 2*b*. This exhibits the form assumed by the secondary pinnæ at the apex. As the pinnæ are traced upwards the pinnules become more and more united to each other till the pinnæ assume the form of much-elongated pinnules with slightly undulating margins. The midrib of these pinnule-like pinnæ gives off dichotomously divided veins. A pinnule from one of the lower pinnæ of this specimen is enlarged seven times at fig. 2*b* to show the nervation.

On a few occasions I have seen small specimens of *Pecopteris cyathea* on which the pinnules show a distinct villose surface, and a small portion of one of these is given at fig. 3, Pl. CXIV. This villosity probably occurs only on the fertile pinnules, and a similar structure has been described by Stur as occurring on this species.* It seems to have been fugaceous, and may have been shed as development of the frond proceeded. Probably it served as a protection to the growing parts.

At Pl. CXVI, fig. 3, is seen a small portion of the apical region of a primary pinna. The alternate secondary pinnæ are linear-lanceolate and for the greater part of their length are of almost equal width, but towards the apex they narrow and end in an obtuse point. Portions of two of these secondary pinnæ are enlarged three times at fig. 3*a*, and show the pinnules at their base. The characteristic nervation of the species is well seen in this figure. It consists of a straight median vein which frequently bifurcates into two arms at its apex and gives off a mixture of slightly ascending simple or once-divided lateral veinlets. Two pinnules are enlarged seven times at fig. 3*b*, Pl. CXVI, to show more distinctly the irregular disposition of the simple and divided veinlets.

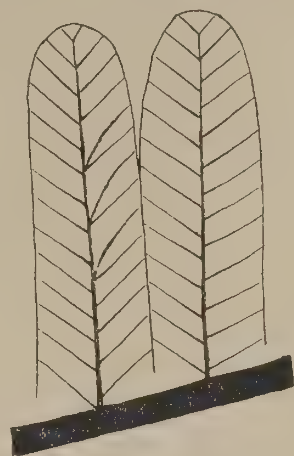
Some isolated fragments of secondary pinnæ of *Asterotheca cyathea* are given on Pl. CXVII, fig. 3, natural size. These have originally held a lower position on the primary pinnæ than those described above. The pinnules are much longer in proportion to their breadth and some of them correspond in size with those given by Schlotheim on his pl. vii, fig. 11.

A few of the pinnæ on this slab exhibit the fructification, but it is apparently in an early state of development and the synangia are only shadowed through the pinnules as their surface is exposed to view. A part of one of these is enlarged three times at fig. 4, Pl. CXVI. A few sterile pinnules from the same slab, also enlarged three times, are given on Pl. CXVII, fig. 3*a*, to show their form. All these figures

* *Scolecopteris cyathea* Schlotheim sp., "Morph. u. Syst. d. Culm-u. Carbonfarne," p. 118, fig. 25A, 1883.

exhibit the characteristic variation in the length of the pinnules that occur side by side on the same pinna. Two pinnules, enlarged six and a half times to show their nervation, are seen at text-fig. 49.

The pinnules of *Asterotheca cyathea* possess a mixture of single and once-bifurcated lateral veinlets, but more frequently the veins are undivided. The bifurcation of the veinlets may take place at the base of the veinlet or at some distance above it.



TEXT-FIG. 49.—*Asterotheca cyathea* Schlotheim sp. Two pinnules enlarged six and a half times to show nervation.

Good figures of the fructification are given by GRAND-'EURY * and ZEILLER. When the synangia are situated on the lateral veinlets, midway between the midrib and the margin of the pinnule, the synangia are equal size,† but when the point of attachment of the synangium is nearer the midrib than the margin, as occasionally it is, then the outer sporangia of the synangium are longer than those next the midrib, as seen on part of the figure given by ZEILLER. In either case, however, the whole of the lower surface of the fertile pinnule is covered by the synangia.

As already mentioned in the description of *Pecopteris arborescens*, some authors have united *Pecopteris cyathea* with that species, but I believe the two to be specifically distinct. They can easily be distinguished by the greater length of the pinnules of *Pecopteris cyathea* in proportion to the width, than is the case in *Pecopteris arborescens*, by their gradually contracting into a blunt point and also by a mixture of simple and bifurcated veinlets which have not been observed to occur in the pinnules of *Asterotheca arborescens*. The irregularity in the size of the pinnules on the same pinna is also a distinctive character of *Asterotheca cyathea*. Its rachis also is smooth or marked merely by faint irregular longitudinal striæ.

Distribution.—*Asterotheca cyathea* Schlotheim sp. has been recorded from all the groups of the Radstockian Series and from the Newcastle-under-Lyme Group of the Staffordian Series. As is the case with *Asterotheca arborescens*, it is possibly more plentiful than records show, for often, on account of imperfect preservation, specimens fail to exhibit the characters necessary for specific determination.

RADSTOCKIAN SERIES.

SOMERSET AND BRISTOL COALFIELD.

RADSTOCK GROUP.

Horizon : ?. *Localities :* Ludlow's Pit and Wellsway Pit, Radstock, Somerset; Norton Hill Colliery, Midsomer Norton, 1½ miles west of Radstock (R. CROOKALL); Upper Conygre Pit, Timsbury, 2½ miles N.N.W. of Radstock.

* "Flore carb. du Départ. de la Loire," *Mém. Acad. Sci., Paris*, xxiv, No. 1, pl. viii, fig. 7.

† ZEILLER, "Flore foss. terr. houil. de Commentry," *Bull. Soc. Ind. min.*, ser. 3, vol. ii, livr. 2, pl. xiii, fig. 1A.

SOUTH WALES COALFIELD.

FARRINGTON GROUP.

Glamorganshire.—*Horizon*: Graigola Seam. *Locality:* Level, about 200 yards south-west of Glyn-coch Farm, Cwm Clydach (Collection of Geological Survey, London).

Horizon: About horizon of Graigola Seam. *Locality:* Clydach Merthyr Colliery, 500 yards W.S.W. of Pen-y-banc Farm (Collection of Geological Survey, London).

Horizon: Aft Vein (=Four-foot Seam). *Locality:* Old Level at Melin Llan, ½ mile north-east of Penller-gare Church (Collection of Geological Survey, London).

Horizon: No. 1 Llantwit Seam. *Locality:* Beddau, near Llantrisant (D. DAVIES).

Horizon: No. 2 Llantwit Seam. *Localities:* Graiglas, near Gilfach Goch (D. DAVIES); Trefyrig, Glynogwr, near Gilfach Goch (D. DAVIES).

AYRSHIRE COALFIELD.

KEELE GROUP.

Horizon: "Red beds." *Localities:* Barony Pit Sinking, Oldbyres Farm, 1½ miles west of Auchinleck; Ochiltree, 11½ miles east of Ayr (JOHN HOWAT).

NORTH DERBYSHIRE AND NOTTINGHAM COALFIELD.

KEELE GROUP.

Horizon: Depth of 900 feet. *Locality:* Thurgarton Boring, 3 miles south of Southwell, 6 miles west of Newark, Nottinghamshire.

NORTH STAFFORDSHIRE COALFIELD.

KEELE GROUP.

Horizon: At depth of 438 feet. *Locality:* Newstead Boring, Trentham.

SHREWSBURY COALFIELD.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: Half-yard Coal. *Locality:* Hanwood Pit, midway between Hanwood and Cruckmeole Villages, 4 miles south-west of Shrewsbury.

NORTH STAFFORDSHIRE COALFIELD.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: ?. *Locality:* Bradwell Wood, Longport.

Asterotheca Candolleana Brongniart sp.

Plate CXVI, figs. 1, 2; text-fig. 50.

1828. *Pecopteris Candolliani* Brongniart, "Prodrome," p. 56.
1833. *Pecopteris Candolliani* Brongniart, "Hist. des végét. foss.," vol. i, p. 305, pl. c, fig. 1.
1838. *Pecopteris Candolleana* Presl in STERNBERG, "Versuch," vol. ii, p. 148.

1843. *Pecopteris Candolleana* Gutbier in GEINITZ, "Gaea v. Sachsen," p. 81.
1853. *Pecopteris Candolliana* Andrae in GERMAR, "Verstein. d. Steink. v. Wettin u. Löbejün," p. 108, pl. xxxviii.
1869. *Pecopteris* (*Cyath.*) *Candolleana* Schimper, "Traité de paléont. végét.," vol. i, p. 500 (*syn. in part*).
1880. *Pecopteris Candolleana* Fontaine and White, "Perm. or Upper Carb. Flora," p. 63 (pl. xx, figs. 1–3 ?).
1880. *Pecopteris Candollei* Zeiller, "Végét. foss. du terr. houil.," *Expl. Carte géol. de la France*, p. 84, vol. iv.
1883. *Pecopteris Candolleana* Renault (*pars*), "Cours de botan. foss.," vol. iii, p. 109, pl. xvii, fig. 7 (*non* figs. 8, 8 bis).
1888. *Pecopteris* (*Asterotheca*) *Candollei* Zeiller, "Flore foss. terr. houil. de Commentry," pt. 1, *Bull. Soc. Ind. min.*, ser. 3, vol. ii, livr. 2, p. 128, pl. xi, fig. 3.
1890. *Pecopteris* (*Asterotheca*) *Candollei* Zeiller, "Bassin houil. et perm. d'Autun et d'Épinac," *Études Gîtes Min. France*, p. 47, pl. viii, figs. 5–6.
1892. *Pecopteris* (*Asterotheca*) *Candollei* Zeiller, "Flore foss. bassin houil. et perm. de Brive," *Études Gîtes Min. France*, p. 14, pl. v, figs. 1–4.
1893. *Pecopteris Candolleana* Potonié, "Flora d. Rothl. von Thüringen," p. 99, pl. vii, figs. 4, 5.
1899. *Pecopteris Candolleana* Hofmann and Ryba, "Leitpflanzen," p. 51, pl. vi, figs. 13, 13*a*.
1903. *Pecopteris Candolleana* Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. i, No. 10, figs. 1, 2A, 2B, 3.
1836. *Cyatheites Candolleanus* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 321.
1855. *Cyatheites Candolleanus* Geinitz, "Verstein. d. Steinkf. in Sachsen," p. 24, pl. xxviii, figs. 12, 13.
1869. *Cyathocarpus Candolleanus* Weiss, "Foss. Flora d. jüngst. Stk. u. Rothl.," p. 85.
1883. *Scolecopteris Candolleana* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 755 (123).
1885. *Scolecopteris Candolleana* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 205.
1833. *Pecopteris affinis* Brongniart (*non* Schlotheim), "Hist. des végét. foss.," vol. i, p. 306, pl. c, figs. 2, 3.
1838. *Pecopteris affinis* Presl in STERNBERG, "Versuch," vol. ii, p. 148 (*ref. in part*).
1883. *Pecopteris affinis* Renault (*non* Schlotheim), "Cours de botan. foss.," vol. iii, p. 109, pl. xvii, fig. 6.
1883. *Scolecopteris affinis* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 755 (123).
1885. *Scolecopteris affinis* Stur, *op. cit.*, p. 203.
1833. *Pecopteris cyathea* Brongniart (*pars*), "Hist. des végét. foss.," vol. i, pl. ci, fig. 4.
1851. Cf. *Pecopteris arborescens* Germar (*non* Schlotheim) (*pars*), "Verstein. v. Wettin u. Löbejün," p. 97, pl. xxxv, fig. 4.

Description.—Frond large, tripinnate. Main rachis smooth or with fine longitudinal striations. Primary pinnæ large, 8 cm. to 15 cm. in breadth, touching each other laterally. Secondary pinnæ alternate, linear, 5 cm. to 10 cm. in length and 1·8 cm. to 2·5 cm. in breadth, of almost equal width till near their summit, where they suddenly contract into an obtuse point.

Pinnules alternate, upright, or slightly oblique to rachis, sometimes a little arcuate, sides parallel, contracted at the base on both sides, or only on the anterior side, when the posterior side is usually decurrent, free or occasionally touching by their margins, sometimes of unequal length, slightly convex, and from three and a half times to five times longer than broad.

Towards the extremity of the frond and of the primary pinnæ, the pinnæ become pinnatifid through the greater or less union of the pinnules, and when these become completely united the pinnæ assume the form of much elongated pinnules.

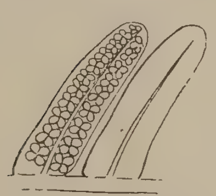
Nervation usually distinct; median vein thick, straight, extending to the apex of the pinnule, sometimes feebly decurrent at the base, lateral veinlets departing at a very wide angle, bifurcating a little above their base into two arms, the anterior fork of which usually again divides. Fertile and sterile pinnæ and pinnules similar in form. Sporangia united in groups of four or five, and forming a star-like synangium, placed on the lateral veinlets about their centre and occupying the whole width of the limb between the midrib and the margin.

Remarks.—Part of a primary pinna is given natural size on Pl. CXVI, fig. 1. The secondary pinnæ are oblique to the rachis, but all are imperfect except the lowest on the right. They are of almost the same width till near the apex, where they suddenly contract into a blunt point.

The pinnules are long, free, contracted at the base on both margins, or only on the anterior margin, and some appear as if narrowed in their lower part, but this appearance is due to the margins being more infolded on the basal portion than on the upper part of the pinnules. This infolding of the margin gives a slight convexity to the pinnules. When the pinnules are flattened out, they are seen to have straight margins and suddenly contract into a blunt rounded apex. This is shown on one of the pinnules enlarged two and a half times at fig. 2, Pl. CXVI.

The pinnules are usually free, but sometimes they are very slightly united, their anterior margin being contracted only at the base, while the posterior margin becomes slightly decurrent.

The veins dichotomize near their base and the anterior arm usually dichotomizes again. Very rarely one of the branches of this secondary dichotomy may again divide. Such a case is seen at the base of the enlarged figure given on Pl. CXVI, fig. 2. No fertile specimens appear to have been met with in Britain, but good figures of the synangia are given by Zeiller,* one showing the arrangement of the synangia on a pinnule is reproduced at text-fig. 50.



Text-fig. 50.—*Asterotheca Candolleana* Brongniart sp. Pinnules enlarged two times. (After Zeiller.)

Asterotheca Candolleana does not appear to be common at any locality, and only fragments of the primary pinnæ are known, none of which, as pointed out by Zeiller, shows its apex or attachment to the main rachis.

The type of *Pecopteris affinis* Brongniart has been compared with the type of *Pecopteris Candolleana* Brongniart by Zeiller, who was convinced of their specific identity; but whether *Pecopteris affinis* Brongniart is the same as *Filicites affinis* Schlotheim,† is a point it seems impossible to determine owing to the absence of any details of the nervation of Schlotheim's specimen.

* "Bassin houil. et perm. d'Autun et d'Épinac.," pl. viii, figs. 5, 5a.

† Schlotheim, "Flora d. Vorwelt," pl. viii, fig. 14; "Petrefactenkunde," p. 404.

The nearest ally to *Asterotheca Candolleana* is *Asterotheca lepidorachis* Brongniart sp.,* which some authors have united with *Asterotheca Candolleana*, but the latter differs in having a smooth rachis, and the pinnules are more distant and contracted at their base.

In the long narrow form of the pinnules *Asterotheca Candolleana* has also some resemblance to *Asterotheca hemitelioides* Brongniart sp., but in the latter all the lateral veins are undivided and the rachises are scaly. These differences easily distinguish the species.

Distribution.—Asterotheca Candolleana is very rare and has been recorded only from the Radstock Group.

RADSTOCKIAN SERIES.

RADSTOCK GROUP.

Horizon: ?. *Localities:* Middle Pit, Radstock, Somerset; Wellsway Pit, near Radstock; Braysdown Colliery, near Radstock; Camerton, 2 miles north of Radstock.

Asterotheca oreopteridia Schlotheim sp.

Plate CXVIII, figs. 1, 1*a*, 2, 2*a*; Plate CXIX, figs. 1–4; text-figs. 51–53.

1804. Schlotheim, "Flora d. Vorwelt," p. 36, pl. vi, fig. 9.
1820. *Filicites oreopteridius* Schlotheim, "Petrifactenkunde," p. 407.
1832. *Filicites oreopteridius* Schlotheim, "Verstein. aus v. SCHLOTHEIM'S Sammlung," p. 6, Kupertafeln, pl. vi.
1826. *Pecopteris oreopteridis* Sternberg, "Essai flore monde prim.," vol. i, fasc. iv, p. xix; vol. ii, fasc. v–vi, pl. xxii, fig. 4; fasc. vii–viii, p. 149.
1879. *Pecopteris oreopteridis* Lesquereux, "Coal Flora," vol. i, p. 238, pl. xli, fig. 8.
1828. *Pecopteris oreopteridius* Brongniart, "Prodrome," p. 56.
1833. *Pecopteris oreopteridia* Brongniart, "Hist. des végét. foss.," vol. i, p. 317, pl. civ, fig. 2 (? fig. 1); pl. cv, figs. 1–3.
1869. *Pecopteris* (*Cyath.*) *oreopteridia* Schimper, "Traité de paléont. végét.," vol. i, p. 502.
1869. *Pecopteris oreopteridia* Weiss, "Foss. Flora d. jüngst. Stk. u. Rothl.," p. 66.
1883. *Pecopteris oreopteridia* Renault, "Cours de botan. foss.," vol. iii, p. 110, pl. xviii, figs. 5, 5 bis; pl. xix, figs. 7–12.
1884. *Pecopteris* (*Asterotheca*) *oreopteridia* Zeiller (*pars*), *Bull. Soc. géol. France*, ser. 3, vol. xiii, p. 138 (*non* pl. ix, figs. 1, 1A).
1888. *Pecopteris* (*Asterotheca*) *oreopteridia* Zeiller, "Flora foss. terr. houil. de Commentry," pt. 1, *Bull. Soc. Ind. min.*, ser. 3, vol. ii, livr. 2, p. 136, pl. xv, figs. 6–8.
1888. *Pecopteris oreopteridia* Kidston, "Foss. Flora Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 371, pl. xxvii, figs. 3, 4; pl. xxviii, figs. 1, 2.
1892. *Pecopteris* (*Asterotheca*) *oreopteridia* Zeiller, "Flore foss. bassin houil. et perm. de Brive," p. 17, pl. v, figs. 7–9.
1893. Cf. *Pecopteris oreopteridia* Potonié, "Flora d. Rothl. von Thüringen," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft 9, Theil 2, p. 68, pl. v, fig. 5; pl. vii, figs. 1–3.

* "Hist. des végét. foss.," pl. ciii, fig. 1 (*non* fig. 5).

1906. *Pecopteris* (*Asterotheca*) *oreopteridia* Zeiller, "Bassin houil. et perm. de Blanzy et du Creusot," fasc. 2, "Flore foss.," *Études Gîtes Min. France*, p. 39.

1916. *Pecopteris oreopteridia* Arber, "Foss. Floras . . . South Staffordshire," *Phil. Trans. Roy. Soc.*, ser. B, vol. ccviii, p. 145, pl. iii, figs. 10, 11.

1899. *Pecopteris oreopteroides* Hofmann and Ryba, "Leitpflanzen," p. 51, pl. vi, figs. 9*a* (? 9).

1836. *Cyatheites oreopteridis* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 323.

1838. *Alethopteris oreopteridis* Presl in Sternberg, "Versuch," ii, fasc. vii–viii, p. 145.

1855. *Cyatheites oreopteroides* Geinitz, "Verstein. d. Steinkf. in Sachsen," p. 25, pl. xxviii, fig. 14.

1883. *Grand'Eurya Renaulti* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 677 (45), fig. 12*c*.

1885. *Grand'Eurya Renaulti* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 104, fig. 16*c*.

Description.—Frond very large, at least tripinnate. Main rachis smooth, attaining a width of 3 cm. or more. Primary pinnæ alternate, spreading almost directly outwards or slightly ascending, linear-lanceolate, margins overlapping each other considerably, 50 cm. or more in length, 15 cm. in width, slightly narrowed at base, contracting somewhat suddenly near the summit and ending in an obtuse or subobtuse point; rachis smooth, 3 mm. to 8 mm. or more in width. Secondary pinnæ alternate, linear-lanceolate, springing at almost right angles from the rachis or slightly ascending, free or touching each other laterally, seldom overlapping to any extent, very gradually tapering from about one-third to one-half their length above the base and ending in a prominent blunt lobe. They attain a length of 10 cm. with a breadth of 1·5 cm. On the upper secondary pinnæ close to the apex, the pinnules gradually become more and more united to each other till at the extreme tip they assume the form of entire, elongated pinnules.

Pinnules alternate, oblong, with blunt rounded apex, more or less convex when uncompressed, upright or slightly oblique to rachis, contiguous, free, or very slightly united to each other, attached by all their base and sometimes slightly decurrent on the posterior side; one and a half to three times longer than broad. The lowest distal basal pinnule is usually larger than the others.

Nervation generally clear and distinct. Median vein straight or very rarely slightly decurrent, extending to the apex, or immediately below the apex dividing into two arms. Lateral veinlets moderately distant, prominent, departing from the median vein at an open angle, most frequently dividing once at or near their base, the upper arm of the fork of the lower or lowest veinlets, in the larger pinnules, sometimes again divides.

Fertile pinnæ and pinnules similar to the sterile ones. Sporangia coriaceous, exannulate, narrowing upwards into a point, united and forming contiguous very prominent synangia. Synangia formed of four or five sporangia of rectangular or circular outline, placed on the lateral veinlets and forming two rows, one on each side of the median vein and covering all the lower surface of the pinnule. The upper surface of the fertile pinnules bears a dense covering of fine short hairs.

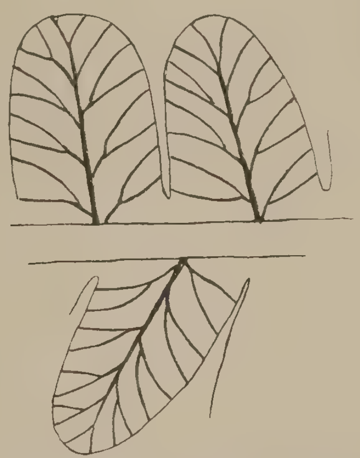
Remarks.—On Pl. CXVIII, fig. 1 (natural size), are shown some portions of primary pinnæ that exhibit the lower surface of the pinnules. The rachises of the primary pinnæ are not exhibited, being all embedded in the matrix. The lower secondary pinnæ are of almost equal width for about a third of their length above their base, then they contract gradually and the pinnæ end in a blunt terminal lobe. The upper pinnæ, however, contract gradually upwards from their base, and are also more distant from each other than those towards the base of the primary pinnæ, where they almost touch.

The pinnules on this example do not seem to have suffered from pressure and are convex, their margins being especially recurved.

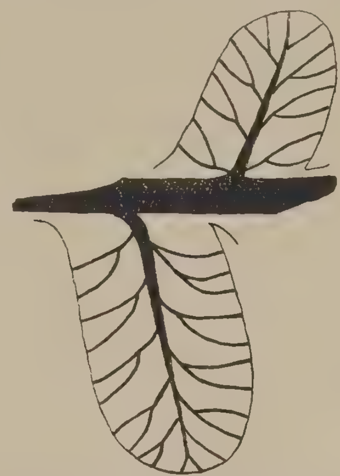
The larger size of the basal pinnules on the posterior side of the pinnæ can be clearly seen at many places on this specimen.

The lateral veinlets on this example, so far as I have been able to observe, are

Text-fig. 51.—*Asteropheca oreopteridia* Schlotheim sp. Pinnule enlarged nine times to show nervation. (From specimen shown on Pl. CXVIII, fig. 1.)



Text-fig. 52.—*Asterotheca oreopteridia* Schlotheim sp. Pinnules enlarged seven times to show nervation. (From specimen shown on Pl. CXVIII, fig. 2*b*.)



Text-fig. 53.—*Asterotheca oreopteridia* Schlotheim sp. (From specimen preserved in the Sedgwick Museum, Cambridge, (No. 3370). (From same locality and horizon as our fig. 2, Pl. CXVIII.)

all only once divided. This is seen in the pinnule enlarged nine times at text-fig. 51.

In further illustration of the nervation of *Asterotheca oreopteridia*, a small specimen is given natural size on Pl. CXVIII, fig. 2. This also exhibits the under surface of the pinnules, and shows the nervation very distinctly, as seen at the enlargement, fig. 2*a*, and text-fig. 52. The lateral veinlets are here slightly more oblique to the median vein than in text-fig. 51.

Text-fig. 53, taken from another specimen, shows in one of the pinnules the bifurcation of the upper arm of a basal lateral veinlet. One of the arms of an upper lateral veinlet may also divide, but this usually happens only in the larger pinnules, where, however, it does not seem to be common.

Part of a fine and very interesting specimen of *Asterotheca oreopteridia* Schlotheim sp. is given natural size on Pl. CXIX, fig. 1.

The complete length of the primary pinna, of which a part is shown on the left side of Pl. CXIX, fig. 1, is 36 cm. and its greater width fully 15 cm. Its central portion is of about equal width, but it contracts towards the base and more suddenly near the apex. The rachis from which this primary pinna springs lies at a slightly lower level on the broken edge of the block at its lower margin, and the rachis of the pinnæ at its base dips into the stone to join it and becomes hidden, but for all practical purposes the primary pinna is complete.

At the base the secondary pinnæ are only 4 cm. to 4·50 cm. in length, while at the broadest part of the pinna their length is fully 7·5 cm. They are very slightly contracted at the base and about one-third their length from the apex, gradually taper upwards and end in a sub-triangular, blunt-pointed, terminal lobe. Towards the base of the primary pinna, the secondary pinnæ slightly overlap. This is seen more on the basal part not shown in the figure. As traced upwards, the secondary pinnæ become more separated, but though their margins may touch, do not overlap.

Portions of two other primary pinnæ occur on the same slab, one on each side of the larger primary pinna seen at fig. 1. The primary pinna that lies on its right hand has been much longer, and that on its left (only shown on the plate by two of the apices of the secondary pinna) is much shorter, so our specimen has probably come from a region of the frond not far below the apex, as it seems to be sharply contracting to a point.

These three primary pinnæ are numbered I, II, and III on the plate. Of No. I only two of the tips of the secondary pinnæ are seen. This primary pinna held the highest position on the frond of the three shown on our specimen. It is sterile throughout. Of No. II four of the basal secondary pinnæ are sterile, those above for a distance of about a third the length of the primary pinna are fertile, but their upper portions are sterile. Of the lowest fertile ones only a few of the pinnules towards their centre bear synangia. The apex and base of all the secondary pinnæ are sterile.

In the other fertile primary pinnæ, No. III of the figure, the upper secondary pinnæ are sterile, all the others are fertile. Of these, all have some sterile pinnules at their apex and at the base of the primary pinna, a few of the secondary pinnæ have one or two sterile pinnules at their base. The most completely fertile pinnules are those situated about the centre of the primary pinna, and as these are traced upwards a gradually increasing number of upper pinnules become barren until at length the completely sterile upper secondary pinnæ are reached.

The margins of the fertile pinnules are recurved or convex. They are slightly narrower and longer than the sterile ones, and have a thick villose covering of short hairs on their upper surface, which is that exposed on our specimen. This is seen at figs. 2 and 3, Pl. CXIX, which are enlarged respectively two and five times. The surface of the sterile pinnules, on the other hand, is entirely free from any trace of villosity. Their margins are also convex or recurved, but to a less extent than seen on the fertile pinnules. The villose covering of the fertile pinnules probably served a protective purpose to the immature synangia. Fig. 2 also shows the upper sterile pinnules, free from all villosity, and the lower villose fertile pinnules.

The nervation is well seen in the sterile pinnules, but is entirely obscured in the fertile ones. The lateral veinlets spring from the median vein at an open angle and divide at or near their base into two arms. Fig. 4, Pl. CXIX.

On the sterile primary pinna No. I, the sterile pinnules are slightly longer than those on the primary pinnæ Nos. II and III. On one of the secondary pinnæ at the base of the primary pinna No. I, the largest pinnules are 9 mm. in length, the same size as the fertile pinnules on the other two primary pinnæ. In those larger pinnules, the lateral veinlets are almost invariably divided into two arms close to their base, in a manner normal to the species. In only a very few cases could I discover the anterior arm of the fork again dividing.

Asterotheca oreopteridia might easily be mistaken for certain forms of *Asterotheca Miltoni* Artis sp. In the latter species, however, all the pinnules, barren and fertile, have a villose covering of short closely-placed hairs, similar to those occurring on the fertile pinnules only of *Asterotheca oreopteridia.* Unfortunately this villose covering of the upper surface of the pinnules seems to have been of a very fugaceous nature, as on many specimens of *Asterotheca Miltoni* it has been shed completely or is seen only in patches. When present, it will at once distinguish the sterile condition of the two species. The nervation of the pinnules of the two plants, however, is different. In *Asterotheca Miltoni,* in the free or slightly united pinnules, the anterior arm of the first dichotomy of the lateral veinlets almost invariably again dichotomizes. In the form of *Asterotheca Miltoni* described by Brongniart under the name of *Pecopteris abbreviata,** where the pinnules are small and more or less distinctly united to each other, the lateral veinlets divide only once, but in these cases the median vein is very distinctly decurrent and the lateral veinlets spring from it at an acute angle.†

Asterotheca oreopteridia is distinguished from *Eupecopteris Bucklandi* Brongniart sp., where also the lateral veinlets usually dichotomize only once, by the obliquity of the decurrent pinnules to the rachis, and the acute angle made by the departing lateral veinlets. The pinnules are also usually longer, and more narrow in proportion to their length and are less obtusely pointed.

Potonié held the view that the plants identified by Brongniart as *Filicites oreopteridius* Schlotheim were not that species, and renamed Brongniart's *Pecopteris oreopteridia, Pecopteris pseudoreopteridia.*‡ This view I cannot accept, as I believe Brongniart's *Pecopteris oreopteridia* is Schlotheim's species, with perhaps the doubtful exception of the specimen he figures on his pl. civ, fig. 1, which, owing to the distance apart of the pinnules on the lowest primary pinna of his specimen, of which an enlargement is given at fig. 1B, may not be referable to Schlotheim's plant, though I am inclined to think that it has been correctly identified by Brongniart.§

* "Hist. des végét. foss.," pl. cxv, figs. 1–4, especially fig. 3.

† See *Asterotheca Miltoni,* Pl. CXX, figs. 3, 3A.

‡ "Flora d. Rothl. v. Thüringen," *Abhandl. k. preuss. geol. Landesanst.,* N.F., Heft 9, Theil 2, 1893, p. 72, pl. viii, figs. 1–4.

§ See Zeiller, "Bassin houil. et perm. de Blanzy et du Creusot," *Études Gîtes Min. France,* 1896, p. 39.

On the other hand, the obliquity of the departure of the lateral veinlets from the median vein and the marked decurrency of the latter, as well as the more acute terminations of the pinnules, seem to separate the plant figured by POTONIÉ under the name of *Pecopteris pseudoreopteridia* from those described by both SCHLOTHEIM and BRONGNIART.

Distribution.—Asterotheca oreopteridia Schlotheim sp. is fairly frequent in the Radstockian Series, but rare in the Staffordian Series, where it has been recorded from the Newcastle-under-Lyme Group and Etruria Marl Group.

RADSTOCKIAN SERIES.

SOMERSET AND BRISTOL COALFIELD.

RADSTOCK GROUP.

Horizon : ?. *Localities :* Radstock, Somerset ; Wellsway Pit, near Radstock, Somerset ; Braysdown Colliery, near Radstock, Somerset ; Camerton, 2 miles north of Radstock, Somerset ; Upper Conygre Pit, Timsbury, 2½ miles N.N.W. of Radstock, Somerset.

SOUTH WALES COALFIELD.

FARRINGTON GROUP.

Horizon : No. 3 Llantwit Seam. *Locality :* Cross Inn, near Llantrisant, Glamorganshire (D. DAVIES).

STAFFORDIAN SERIES.

SOMERSET AND BRISTOL COALFIELD.

NEWCASTLE-UNDER-LYME GROUP.

Horizon : ?. *Locality :* Parkfield Colliery, near Pucklechurch, Gloucestershire (R. CROOKALL).

KENT COALFIELD.

ETRURIA MARL GROUP.

Horizon : At depth of 1760 feet. *Locality :* Boring at Tower Brickworks, Folkestone (Collection of Geological Survey, London).

SOUTH STAFFORDSHIRE COALFIELD.

ETRURIA MARL GROUP.

Horizon : Old Hill Marls, within the upper 300 feet of the group. *Locality :* Granville Pit, Old Hill Station, 1½ miles north-east of Halesowen (Rev. H. KAY).

Asterotheca Miltoni Artis sp.

Plate CXX, figs. 1–5; Plate CXXI; Plate CXXII, fig. 1; text-figs. 48 and 54–57.

1825. *Filicites Miltoni* Artis, "Antediluvian Phytology," pl. xiv.
1828. *Pecopteris Miltoni* Brongniart, "Prodrome," p. 58.
1834. *Pecopteris Miltoni* Brongniart (*pars*), "Hist. des végét. foss.," p. 333, pl. cxiv, fig. 8 (*non* figs. 1–7).
1849. *Pecopteris Miltoni* Andrae in Germar, "Verstein. d. Steink. v. Wettin u. Löbejün," p. 63, pl. xxvii (*refs. in part*).
1880. Cf. *Pecopteris Miltoni* Fontaine and White, "Perm. or Upper Carb. Flora of W. Virginia and S.W. Pennsyl.," p. 65 (pl. xxiii, figs. 2, 3 ?).
1886. *Pecopteris Miltoni* Sterzel, "Die Flora d. Rothl. in nordwest. Sachsen," *Palaeont. Abhandl., Jena*, Band iii, Heft 2, p. 240 (p. 6, pl. i (xxi), figs. 1–7) (*Excl.* syn. *Pec. polymorpha*).
1888. *Pecopteris Miltoni* Kidston, "Foss. Flora of the Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 374, text-figs. 2–4 (p. 376), 5 (p. 379).
1890. *Pecopteris Miltoni* Grand'Eury, "Géol. et paléont. du bassin houil. du Gard," p. 273.
1899. *Pecopteris* (*Asterotheca*) *Miltoni* Zeiller, "Flore foss. du bassin houil. d'Héraclée," *Mém. Soc. géol. France, Paléont.*, no. 21, p. 32.
1901. *Pecopteris* (*Asterotheca*) *Miltoni* Kidston, "Flora of Carboniferous Period," *Proc. Yorks. Geol. and Polytech. Soc.*, vol. xiv, pt. 2, pp. 194, 209, pl. xxvii, fig. 4.
1899. *Pecopteris Miltoni* Hofmann and Ryba, "Leitpflanzen," p. 53, pl. vii, figs. 3, 3*a*.
1903. *Pecopteris Miltoni* Arber, "Foss. Plants Ardwick Series," *Mem. & Proc. Manchester Lit. & Phil. Soc.*, vol. xlviii, pt. 1, p. 17, pl. i, fig. 4.
1907. *Pecopteris* (*Asterotheca*) *Miltoni* Zalessky, "Flore Foss. Donetz," I, *Bull. Comité géol. Russie*, vol. xxvi, p. 390, pl. xiv, figs. 5, 7, 8, 10, 10*a* (? *non* figs. 11, 11*a*).
1907. *Pecopteris* (*Asterotheca*) *Miltoni* Zalessky, "Flore Foss. Donetz," II, *Bull. Comité géol. Russie*, vol. xxvi, p. 460, pl. xx, figs. 3, 3*a*, 3*b*, 8, 8′, 8″.
1908. *Pecopteris* (*Asterotheca*) *Miltoni* Nathorst, *K. Svenska Vetenskapsakad. Handl.*, Band xliii, No. 6, p. 8, pl. i, figs. 13, 14.
1912. *Pecopteris Miltoni* Arber, "Fossil Plants of Forest of Dean Coalfield," *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 3, p. 331, pl. xxxvii, fig. 2.
1914. *Pecopteris Miltoni* Stopes, "The 'Fern Ledges' Carboniferous Flora of St John, New Brunswick," *Canada, Dept. of Mines, Geol. Survey, Mem. 41*, p. 41, pl. vii, figs. 14–17, and text-figs. 5, 6.
1915. *Pecopteris Miltoni* Jongmans and Gothan, "Palaeobot.-Strat. Studien," *Archiv. für Lagerstättenforschung*, No. 18 (*K. preuss. geol. Landesanst.*), p. 174, pl. v, figs. 4, 4*a*.
1922. *Pecopteris Miltoni* Gothan, "Leitfossilien," Lief. 3, Karbon u. Perm., p. 49, pl. xii, fig. 2.
1918. *Pecopteris Miltoni* forma *abbreviata* Sterzel, "Organ. Reste d. Kulm. u. Rothl. Chemnitz," p. 285, pl. viii, fig. 84; pl. xv, figs. 18*a*–18*e*.
1869. *Pecopteris* (*Cyath.*) *Miltoni* Schimper, "Traité de paléont. végét.," vol. i, p. 505.
1836. *Cyatheites Miltoni* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 324.
1845. *Cyatheites Miltoni* Unger, "Synop. plant. foss.," p. 88.
1855. *Cyatheites Miltoni* Geinitz (*pars*), "Verstein. d. Steinkf. in Sachsen," p. 27, pl. xxx, fig. 5 (6 ?), var. *abbreviata*, pl. xxx, figs. 7, 8; pl. xxxi, figs. 1, 2 (3, 4 ?) (*refs. in part*).
1880. *Cyatheites Miltoni* Rothpletz, "Die Steinkohlf. Ostseite der Todi," *Abhandl. Schweiz. Palaeont. Gesellsch.*, Band vi, p. 8, pl. ii, fig. 6.
1877. *Hawlea Miltoni* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 293.
1883. *Hawlea Miltoni* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzb. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 683 (51), fig. 13*a*, *b* (? *c*, *d*).

1885. *Hawlea Miltoni* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 108, pl. lix, figs. 1, 2 (? 3), 4; pl. lx, figs. 1 (? 2) (*non* figs. 3, 4), text-fig. 17, p. 106 (*syn. in part*).
1888. *Hawlea Miltoni* Schenk, "Die Fossilen Pflanzenreste," p. 28, fig. 23 (2).
1828. *Pecopteris abbreviata* Brongniart, "Prodrome," p. 56.
1835. *Pecopteris abbreviata* Brongniart, "Hist. des végét. foss.," vol. i, p. 337, pl. cxv, figs. 1–4.
1836. *Pecopteris abbreviata* Lindley and Hutton, "Fossil Flora," vol. iii, pl. clxxxiv.
1882. *Pecopteris abbreviata* Zeiller, "Note sur la flore houil. des Asturies," *Mém. Soc. géol. du Nord*, p. 12.
1886. *Pecopteris* (*Asterotheca*) *abbreviata* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 186, pl. xxiv, figs. 1–4.
1890. *Pecopteris abbreviata* Grand'Eury, "Géol. et paléont. du bassin houil. du Gard," p. 272, pl. xx, fig. 4.
1893. *Pecopteris abbreviata* Potonié, "Flora d. Rothl. von Thüringen," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft 9, Theil 2, p. 76 (? pl. viii, fig. 5; pl. xiii, fig. 5).
1877. *Hawlea abbreviata* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 393.
1826. *Pecopteris crenata* Sternberg, "Essai flore monde prim.," vol. i, fasc. iv, p. xx; vol. ii, p. 154, pl. x, fig. 7.
1845. ? *Hawlea pulcherrima* Corda, "Flora d. Vorwelt," p. 90, pl. lvii, figs. 7, 8.
1833. Cf. *Pecopteris villosa* Brongniart, "Hist. des végét. foss.," p. 316, pl. civ, fig. 3.
1855. *Cyatheites villosus* Geinitz (? Brongniart), "Verstein. d. Steinkf. in Sachsen," p. 25, pl. xxix, figs. 6, 7 (? *non* fig. 8).
1869. *Goniopteris* (*Desm.*) *brevifolia* Schimper, "Traité de paléont. végét.," vol. i, p. 546.
1885. *Hawlea saxonica* Stur, "Carbon-Flora d. Schatzlarer Schichten" (*loc. cit.*), p. 108.
1899. Cf. *Pecopteris vestita* White (Lesquereux ?), "Fossil Flora of Lower Coal Measures of Missouri," p. 91, pl. xxvi, fig. 1; pl. xxxiii, figs. 1–5 (*cf.* figs. 6, 7).
1912. *Pecopteris polymorpha* Arber (*non* Brongniart), "Foss. Flora Forest of Dean," *Phil. Trans. Roy. Soc.*, ser. B, vol. ccii, p. 249, pl. xi, fig. 7.
1914. *Pecopteris integra ?* Arber (*non* Andrae), "Foss. Flora Forest of Wyre," *Phil. Trans. Roy. Soc.*, ser. B, vol. cciv, p. 392, pl. xxvii, fig. 15.

Description.—Frond very large, quadripinnate. Main rachis about 3 cm. in breadth at lower part of frond, smooth or striated, rarely punctate. Primary pinnæ alternate, their margins touching or overlapping, attaining a length of at least 60 cm. and a width of 20 cm., broadly lanceolate, gradually tapering for about two-thirds of their length, then contracting more suddenly and ending in a sharp point; rachis straight and almost invariably smooth or with faint longitudinal striations. Secondary pinnæ alternate, rachis straight, attaining a length of 5 cm. or more and a width of 1·2 cm., free or their margins touching, linear-lanceolate, spreading almost straight outwards or more or less ascending, sometimes slightly contracted at base or of almost equal width for the lower two-thirds of their length, then narrowing and terminating in a blunt point. Rachis straight, almost invariably smooth. Tertiary pinnæ on lower region of frond 2·50 cm. or more in length, and 7 mm. or more in width at base, free or touching by their margins, broadly linear or linear-lanceolate, of almost equal width till near the apex, where they suddenly contract and form a very blunt end. Rachis straight.

Pinnules alternate, varying greatly in size according to the position held on the frond by the pinnæ bearing them, from 2 mm. to 8 mm. in length and 2 mm. to 4 mm. in breadth, almost upright to rachis or more or less oblique, sometimes with a slight curvature, when uncompressed very convex at margins, sides straight and parallel and suddenly terminating in a broad blunt apex, rarely quite free, usually slightly or more or less united to each other. On the lower and middle primary pinnæ, the pinnules on the secondary pinnæ holding lower positions are only very slightly united to each other or may be free and slightly decurrent; on the higher placed pinnæ they are more or less united, and, as the secondary pinnæ are traced towards the apex of the primary pinnæ, the pinnules become more and more united to each other till near the apex the pinnules are only represented by the crenate margins of the pinnæ, while at the apex they are reduced to the form of elongated entire pinnules. On the tertiary pinnæ the pinnules are small, as broad as long or only slightly longer than broad, with blunt apices, and for the most part nearly at right angles to the rachis; on the lower pinnæ they are free or only very slightly connected by their bases to each other, and not till near the apex do they become more united. On the upper tertiary pinnæ the pinnules become gradually more and more united to each other till the pinna has merely a crenate margin, and finally the pinnæ assume the form of elongated pinnules. The surface of all the pinnules has a dense covering of small fine adpressed hairs on their upper surface.

Nervation.—When the villose covering is preserved on the surface of the pinnules the nervation is obscured, and even when this has been removed it is seldom very distinctly seen. The median vein extends to near the apex where it usually bifurcates, is straight throughout its whole course in the pinnules, placed at right angles to the rachis, but in those oblique to the rachis it is slightly decurrent, and in the more or less confluent pinnules of the uppermost pinnæ it is prominently decurrent. Lateral veinlets are given off at a somewhat open angle and dichotomize near their base once or twice; in the larger pinnules the lower arm usually remains undivided, while the upper arm again dichotomizes, more rarely both arms divide, but mixed with these, some of the lateral veins are seen to undergo only one dichotomy. On the shorter, more highly situated pinnæ, the lateral veinlets usually dichotomize only once, though sometimes the upper arm of the fork may again divide. On the secondary pinnæ at the extreme apex, where the pinnules are united to each other throughout the greater part of their length, the median vein is very distinctly decurrent and gives off undivided lateral veinlets.

On the tertiary pinnæ situated in the lower and central regions of the secondary pinnæ, the free or only slightly united pinnules have a straight median vein which gives off once-divided lateral veinlets; on the tertiary pinnæ situated in the apical region of the secondary pinnæ, where, through the almost complete union of the pinnules the tertiary pinnæ have only a crenate margin, the decurrent median vein gives off simple undivided lateral veinlets.

Fertile pinnæ and pinnules similar in form to the sterile ones. The secondary pinnæ on the upper third of the primary pinnæ and frequently the basal secondary pinnæ are sterile. The apical portion, and sometimes the basal region of the fertile secondary pinnæ, is also sterile. Sporangia exannulate, coriaceous, oval pointed at the summit, 0·75 mm. in length and from 0·40 mm. to 0·50 mm. in breadth, united to each other and forming synangia composed of three to five sporangia, most commonly of four sporangia, upright and closely adpressed to each other, placed on the lateral veinlets at an equal distance from the median vein and the margin of the pinnule and form little blunt-pointed stars. At maturity the sporangia forming the synangia seem to separate and, bending outwards, lie horizontally on the surface of the pinnule, almost covering the entire under surface. Dehiscence takes place by a longitudinal cleft passing down the middle of their ventral surface. Spores circular in outline, about 40 μ in diameter, with a very fine granulation on their outer surface and a triradiate ridge.

Remarks.—Asterotheca Miltoni is the most common and widely distributed species of *Asterotheca* found in Britain, but it generally occurs in a fragmentary condition. The fronds were of great size, but as the specimens show only small portions of different regions it is necessary to piece together these fragments, in order to gain a general idea of the frond.

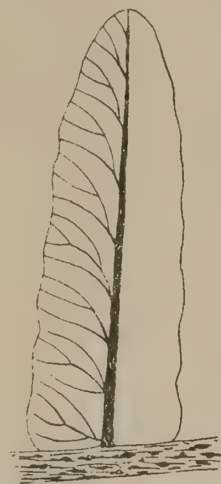
The causes that bring about the modifications in the size and form of the pinnules, and the extent to which they are united to each other, are in direct relation to the position held by the pinna on the frond that bears them. These modifications are repeated in each pinna, as well as in the apical regions of the frond. By the constancy of their occurrence one can usually refer the various fragments to their approximate original position in the pinnæ or apical region of the frond. Sometimes, however, it may be impossible to determine from which of these regions certain specimens were derived, since the same modifications are observable in the form, size, and greater or less union of the pinnules.

The specimen given natural size on Pl. CXXII, fig. 1, shows fragments of two primary pinnæ from the basal region of the frond, where it attains its maximum degree of division and becomes quadripinnate. The tertiary or ultimate pinnæ are short, of almost equal width till near their summit, where they suddenly contract into a very blunt termination. The convex pinnules are small, as broad as long or slightly longer than broad, and are attached by the whole width of their base. On the tertiary pinnæ holding lower positions, as seen at the base of the figure, the pinnules are free or connected only at their extreme base, have straight sides and very blunt apices. The straight median vein joins the rachis at almost a right angle and gives off lateral veinlets which, where observable, dichotomize once. On the tertiary pinnæ holding a higher position on the secondary pinnæ the pinnules become more and more united to each other, and at the apex of the secondary pinnæ the tertiary pinnæ assume the form of entire, much elongated pinnules.

Of the two primary pinnæ shown on Pl. CXXII, it can be observed that, on the fragment of the one which held the higher position on the frond (seen at the upper end of the figure), the pinnules become more united to each other, as seen on the pinnæ enlarged three times at fig. 1*a*.

A fragment of another quadripinnate condition of the frond is given on Pl. CXXI, fig. 4, natural size. This specimen held a higher position on the primary pinnæ than those just described. One can trace here from the base to the apex the gradually increasing union of the pinnules to each other, till at the top of the specimen the tertiary pinnæ are assuming the form of pinnules. At fig. 4*a* some of these tertiary pinnæ are enlarged three times to show the almost complete union of the pinnules, whose individuality is now represented only by the obscure blunt lobes at the margin and the corresponding convexities in the pinnæ.

A pinna from a slightly higher level on the same specimen than that given at fig. 4*a*, Pl. CXXI, is enlarged six and a half times at text-fig. 54. Here the pinna has almost assumed the form of a pinnule, though the component pinnules of which it is formed can still be individually recognised. In the lower part their median vein gives off simple lateral veinlets, while the nervation above approaches much more that of a pinnule.



TEXT-FIG. 54.—*Asterotheca Miltoni* Artis sp. Upper tertiary pinna showing almost complete union of pinnules and nervation. Enlarged six and a half times.

The rachis of this specimen is distinctly punctate, the only case of the kind that I have seen. The little pits caused by the apiculi can be seen on the rachis in the figure, and a few can also be observed on the rachis of the enlargement, fig. 4*a*, Pl. CXXI. These have previously been observed by ZEILLER * on the rachis of *Asterotheca Miltoni*.

The specimen given on Pl. CXXI, fig. 2, is part of a tripinnate primary pinnæ from the central region of the frond, and shows portions of secondary pinnæ none of which is perfect, but the more complete are seen to narrow more gradually in their apical portion than those on tertiary pinnæ (Pl. CXXI) which suddenly contract and terminate in very blunt apices. The pinnules are free, slightly oblique to the rachis, about twice as long as broad, and end bluntly. Some of the pinnules are slightly rounded at the base on their anterior margin, and are decurrent on the posterior margin. Part of a pinna is enlarged three times at fig. 2*a*. At the apex the pinnules are still almost free, but show a slight decurrence at their base on the posterior margin. The median vein is straight and gives off lateral veinlets which usually divide once, but occasionally the upper arm of the fork again divides. The short villose hairs on the upper surface of the pinnules have been almost entirely shed or decayed, and occur only in small patches; on account of their absence the nervation is distinctly seen. A pinnule is enlarged six and a half times at text-fig. 55 to show these features.

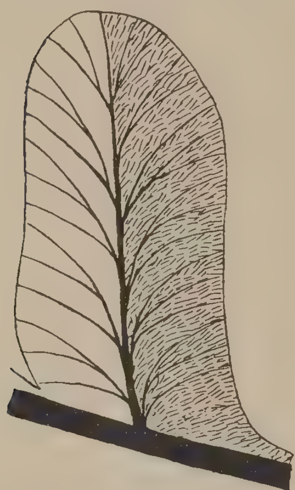
TEXT-FIG. 55.—*Asterotheca Miltoni* Artis sp. Pinnule enlarged six and a half times to show attachment to rachis and the nervation.

* ZEILLER, *Pecopteris abbreviata* (=*Asterotheca Miltoni*), "Végét. foss. du terr. houil. de la France," *Explan. Carte géol. France*, vol. iv, p. 85, 1880; ZEILLER, "Notes flore houil. des Asturies," *Mém. Soc. géol. du Nord*, vol. i, No. 3, p. 13, 1882.

A small fragment of a secondary pinna is given enlarged three times at fig. 1, Pl. CXX. This pinna probably held a position on the frond somewhat similar to that last described. The pinnules are scarcely twice as long as broad, some are slightly decurrent and have a sinus at their base on the anterior margin. At a few places the pinnules show the short adpressed hairs on their surface.

The lateral veinlets dichotomize near their base. In the lower part of the pinnule the upper arm usually again divides, while towards the apex the lateral veinlets divide only once. (Text-fig. 56.)

Portions of a few secondary pinnæ are enlarged three times at fig. 3, Pl. CXX. They occupied a higher position on a primary pinna than the two last described, but probably from the same region of the frond. The pinnules are about 4 mm. in length and 2·5 mm. in breadth. At the base of the pinnæ they are united to each other for about one-quarter to one-third of their length, but as traced towards the apex of the pinnæ the pinnules become more and more united till at the apex they run together and form a long terminal lobe with a crenate margin. All the pinnules are more or less united on this small example, and when such is the case the median vein is also decurrent. In these smaller pinnules the lateral veinlets are generally only once divided, as seen at fig. 3*a*, which is enlarged seven times.



Text-fig. 56.—*Asterotheca Miltoni* Artis sp. Pinnule enlarged seven times to show nervation and form of pinnule.

A primary pinna, probably from near the apex of a frond, is given at fig. 3, Pl. CXXI, natural size. On the secondary pinnæ at the base of the specimen the pinnules are united for about half their length. As the pinnæ are traced upwards, the pinnules become more and more united to each other till at the apex they assume the form of elongated pinnules.

Two secondary pinnæ from immediately below the apex of a primary pinnæ, or possibly from the apical portion of a frond, are enlarged three times at fig. 1, Pl. CXXI. The pinnules here are only individually recognisable by the blunt lobes which form the crenate margin to the pinnæ. The decurrent median vein gives off steeply-ascending simple lateral veinlets which all terminate in the margin of the blunt lobe that represents their apex. The figure shows the shagreen-like upper surface of the pinnules, caused by the presence of the short villose hairs on their surfaces.

A small specimen from the fertile portion of a primary pinna, which shows its lower surface, is given natural size at fig. 4, Pl. CXX. The synangia, usually composed of four sporangia arranged in the form of a little star, form two rows, one row on each side of the median vein, and cover almost the entire under surfaces of the pinnules.

On this example the pinnules are fertile from the extreme base upwards as far as the pinnæ are preserved, but none of them show the complete apex. That in the upper corner of the figure is almost complete and all the pinnules are fertile, but most frequently the basal and apical pinnules are sterile or bear only a few synangia. The larger pinnules have five or six synangia on each side of the median vein, but on the great majority of the pinnules the number is four, though this decreases with the reduction in the size of the pinnules in the apical region.

The tips of three fertile secondary pinnæ, which also exhibit the lower surface, are given natural size at fig. 2, Pl. CXX. Except the terminal lobe and the two little pinnules attached to its base, all are fertile, but some of the uppermost pinnules have very few synangia. A part of the specimen is enlarged six and a half times at fig. 2*a* to show the sporangia. They are uncompressed and of an oval form, and the little star-shaped synangia seem to have been generally formed of four sporangia. This is seen at several places on the figure. A single synangium, more highly enlarged, is given at fig. 2*b*. As the sporangia still retain their rotundity, dehiscence has apparently not yet taken place.

TEXT-FIG. 57.—Spore of *Asterotheca Miltoni* enlarged 500 times. After NATHORST. (The fine granulation of the outer surface is not shown on the figure.)

At fig. 5, Pl. CXX, a single synangium is enlarged about fifteen times. It is one of a number which occur on a small fragment of clay ironstone. There are no distinguishable remains of the pinnules which bore them, but from the horizon from which the specimen was obtained it probably belongs to *Asterotheca Miltoni*. The synangia, however, are larger than usual for this species, the one figured being 3 mm. in diameter. In any case it illustrates their structure very well. It has evidently shed its spores and is in a collapsed condition. The sporangia show a ridge running along the whole length of their ventral surface which most probably arises from the edges of the cleft, through which the spores were shed, being pressed together. The walls of the sporangia must have been formed of a very firm coriaceous tissue which is composed of small but elongated cells. These are shown on the lower sporangium.

The spores of *Asterotheca Miltoni* have been described by NATHORST,* and one of them is reproduced at text-fig. 57. They are circular in outline, with a finely granular surface and triradiate ridge. They measure about 40 μ in diameter.

The plant with which *Asterotheca Miltoni* is most likely to be mistaken is *Scolecopteris polymorpha* Brongniart sp., but the latter differs in not having the villose covering of small adpressed hairs on the pinnules and in the lateral veinlets being usually divided twice; the ultimate divisions of the latter are closer than those of *Asterotheca Miltoni*. The tertiary pinnæ also gradually taper from the base upwards and terminate in sharp points, whereas the corresponding pinnæ of *Asterotheca Miltoni* are of almost equal width till near the apex, where they suddenly contract and end in very blunt apices. All the specimens figured by BRONGNIART under the name of *Pecopteris Miltoni* on his pl. cxiv belong to *Scolecopteris polymorpha*, with the exception of his fig. 8.

* *Loc. cit.*

It is very probable that *Pecopteris villosa* Brongniart * belongs to *Asterotheca Miltoni* Artis sp., but it seems impossible to settle this point satisfactorily. There can be no doubt, however, that *Cyatheites villosus* Geinitz † is the *Asterotheca Miltoni* Artis sp.

Dr Marie Stopes has shown from a study of the original specimens (*loc. cit.*) that *Sphenopteris pilosa* Dawson,‡ the *Callipteris pilosa* Dawson,§ and *Pecopteris* (*Cyatheites ?*) *densifolia* Dawson (*non* Göppert ‖) must all be referred to *Asterotheca Miltoni*. The figures of these species given by Dawson are unsatisfactory representations of badly preserved specimens.

Pecopteris abbreviata ? Lesquereux ¶ has been shown by Sellards ** to be the sterile foliage of *Crossotheca sagittata* Lesquereux.

Pecopteris vestita Lesquereux †† has a very close resemblance to *Asterotheca Miltoni*, and this resemblance seems to approach identity in the figures of that species given by White. ‡‡ His pl. xxvi, fig. 1, and pl. xxxiii, figs. 1–5 (? 6, 7) seem to agree perfectly with *Asterotheca Miltoni*, but in the description of the species (p. 92) he describes the pinnules as being "either rather densely covered with short scales or scaly hairs lying parallel to the nervation, or, when macerated, appearing brownish or transparent, the scaly covering usually remaining, however, in portions of the specimen." On the pinnules of *Asterotheca Miltoni* the dense villose covering of small hairs could scarcely be described as scales, and this is the only difference I can discover between the two species. I have not, however, had an opportunity of comparing authentic specimens.

Distribution.—Asterotheca Miltoni Artis sp. is by far the most common member of the genus in Britain. It appears at the base of the Westphalian Series and, as traced upwards, becomes increasingly more common and is a characteristic species of that Series. In the upper part of the Staffordian Series and in all the Groups comprised in the Radstockian Series it is very common.

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon : ?. *Localities :* Radstock, Somerset ; Braysdown Colliery, near Radstock, Somerset ; Wellsway Pit, near Radstock, Somerset ; Lower Conygre Pit, Timsbury, 2½ miles N.N.W. of Radstock, Somerset ; Welton, 1½ miles west of Radstock, Somerset ; Camerton, 2 miles north of Radstock, Somerset.

* "Hist. des végét. foss.," p. 316, pl. civ, fig. 3.

† "Verstein. d. Steinkf. in Sachsen," p. 25, pl. xxix, figs. 6–7 (? 8).

‡ "Acadian Geology," 2nd ed., p. 552.

§ "Foss. Plants Devon. and Upper Silur. Forms. of Canada" (*Geol. Survey of Canada*), p. 51, pl. xvi, fig. 189, 1871.

‖ "Foss. Flora Devon. and Upper Silur. Formations," p. 56, pl. xvii, figs. 195, 196, 1871.

¶ "Coal Flora," vol. i, p. 248, pl. xlvi, figs. 4–6.

** "On the Fertile Fronds of *Crossotheca* and *Myriotheca*, etc.," *Amer. Journ. Sci.*, vol. xiv, p. 196, 1902.

†† "Coal Flora," p. 252, pl. xliii, figs. 1–4 (? 5), 6, 7.

‡‡ "Fossil Flora of the Lower Coal Measures of Missouri," *Mon. U.S. Geol. Survey*, vol. xxxvii, 1899.

Forest of Dean Coalfield.

FARRINGTON GROUP.

Horizon: Woorgreens Coal. *Locality:* Woorgreens Colliery, near Cinderford Bridge Station, Gloucestershire (E. A. N. Arber).

Somerset and Bristol Coalfield.

FARRINGTON GROUP.

Horizon: ?. *Locality:* Farrington Gurney, near Radstock, Somerset.

South Wales Coalfield.

FARRINGTON GROUP.

Glamorganshire.—*Horizon:* Four-foot Seam (=Aft Seam). *Localities:* Old Levels at Melin Llan, ½ mile north-east of Penller-gare Church (Collection of Geological Survey, London); Gladys Colliery, 1 mile E.S.E. of Penller-gare Church (Collection of Geological Survey, London); Groves End Colliery, 300 yards north of Groves End.

Horizon: 130 yards above Gelli Seam. *Locality:* Groves End Colliery, 300 yards north of Groves End (Collection of Geological Survey, London); New Groves End Colliery, 600 yards north of Groves End (Collection of Geological Survey, London).

Horizon: Graigola Seam. *Localities:* Level about 200 yards south-west of Glyn-coch Farm, Cwm Clydach (Collection of Geological Survey, London); Craig Cwm Level No. 2, about 500 yards north of Glyn-coch Farm, Cwm Clydach (Collection of Geological Survey, London).

Horizon: About horizon of Graigola Seam. *Locality:* Clydach Merthyr Colliery, 500 yards W.S.W. of Pen-y-banc Farm (Collection of Geological Survey, London).

Horizon: No. 2 Llantwit Seam (=Mynyddislwyn Seam). *Localities:* Old Gelligaer Colliery (Llancaich No. 1), ½ mile south-east of Llancaich Station (Collection of Geological Survey, London); Old Furnace, close to Penyrheol Station (Collection of Geological Survey, London); Old Rhosllantwit Colliery, about 1 mile north-east of Caerphilly Castle (Collection of Geological Survey, London); Eneu'r glyn Old Colliery, ¾ mile south of Llanbradach Station (Collection of Geological Survey, London); Graiglas, near Gilfach Goch (D. Davies); Trefyrig, Glyngwr, near Gilfach Goch (D. Davies); Tynygraig, Glyngwr, near Gilfach Goch (D. Davies).

Horizon: Pen-y Scallen Seam. *Locality:* Cape Colliery, 1 mile north-east of Gowerton Station (Collection of Geological Survey, London).

Monmouthshire.—*Horizon:* No. 2 Llantwit Seam (=Mynyddislwyn Seam). *Localities:* Gelli-deg Level, Maes-y-Cwmmer (Collection of Geological Survey, London); Lebanus Colliery, near road side, ⅔ mile north of Tredegar Junction Station (Collection of Geological Survey, London); Gwernau Level, ⅓ mile east of

Boot (Collection of Geological Survey, London); Bryngwyn Old Colliery, ½ mile north-west of Bedwas (Collection of Geological Survey, London).

Horizon: No. 3 Llantwit Seam. *Locality:* Castellau, near Beddau (D. Davies).

Ayrshire Coalfield.

keele group.

Horizon: "Red Beds." *Localities:* Barony Pit, Old Byres Farm, about 1½ miles west of Auchinleck; Back O' Hill, Burnock Water, Ochiltree Parish (J. Smith).

Forest of Wyre Coalfield.

keele group.

Horizon: At depth of 876–878 feet and 1100 feet. *Locality:* Claverley Boring, 5 miles east of Bridgnorth, Shropshire (Collection of Geological Survey, London).

Kent Coalfield.

keele group.

Horizon: At depth of 1880 and 1886 feet. *Locality:* Bere Farm Boring, 1¾ miles north-east of Dover (Collection of Geological Survey, London).

North Staffordshire Coalfield.

keele group.

Horizon: At depths of 117 and 120 feet. *Locality:* Newstead Boring, Trentham.

South Staffordshire Coalfield.

keele group.

Horizon: ?. *Locality:* Hamstead Colliery Sinking, Great Barr, 2½ miles south-east of Walsall.

Warwickshire Coalfield.

keele group.

Horizon: ?. *Locality:* Foleshill Clay Pit, Coventry (R. D. Vernon).

STAFFORDIAN SERIES.

Forest of Dean Coalfield.

newcastle-under-lyme group.

Horizon: ?. *Localities:* Great Western Colliery, near Speech House, Gloucestershire; Trafalgar Colliery, near Drybrook, Gloucestershire; Lightmoor Colliery, near Cinderford Bridge, Gloucestershire (E. A. N. Arber); New Fancy Colliery, 2 miles south of Speech House, Gloucestershire (E. A. N. Arber); Park End Colliery, south end of Forest of Dean, Gloucestershire (E. A. N. Arber).

Horizon : Yorkley Coal. *Locality :* Flour Mill Colliery, 1 mile north-west of Park Gutter, Whitecroft Station, Gloucestershire (E. A. N. Arber).

Forest of Wyre Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon : Roof of Soft Coal (=Main Sulphur Coal ?). *Locality :* Mamble Colliery, Mamble, Worcestershire (Collection of Geological Survey, London).

Horizon : Sulphur Coal. *Localities :* Buckets Leasow, about 2 miles north-west of Pensax, Worcestershire (Rev. H. Kay) ; Gybhouse Colliery, about 1½ miles east of Bayton, Worcestershire (Rev. H. Kay).

Horizon : Roof of Three-quarter Seam (=Main Sulphur Coal ?). *Locality :* Bayton Colliery, Bayton, Worcestershire (Collection of Geological Survey, London).

North Staffordshire Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon : Base of Group. *Localities :* Borehole, Keele Hall ; Drain Cutting, Basford, 3½ miles south of Leek (J. Ward).

Horizon : ?. *Localities :* Railway Tunnel, Newcastle-under-Lyme ; Newstead Boring, Trentham.

Shrewsbury Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon : Half-yard Coal. *Locality :* Hanwood Pit, midway between Hanwood and Cruckmeole Villages, 4 miles south-west of Shrewsbury, Shropshire (Collection of Geological Survey, London).

Horizon : ?. *Localities :* Arscott Pit tip, 1 mile south-east of junction of Welshpool and Minsterly Railway lines, Shropshire (Collection of Geological Survey, London) ; Bausley ; old shaft 250 yards south-west of road at Coedway bank (Collection of Geological Survey, London).

Somerset and Bristol Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon : ?. *Localities :* Parkfield Colliery, near Pucklechurch, Gloucestershire (R. Crookall) ; Bromley Colliery, 1 mile west of Pensford, Somerset (R. Crookall).

North Wales Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon : Coedyrallt Group. Shales associated with Morlas Main Coal. *Locality :* Ifton Heath Old Colliery, 2½ miles east of Chirk Station, Denbighshire (Collection of Geological Survey, London).

Warwickshire Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: At depth of 1670 feet. *Locality:* Whitmore Park Boring, near Coventry (R. D. Vernon).

Horizon: At depth of 200 feet. *Locality:* Well Sinking at Griff Colliery, Clare Pit, 2½ miles south-west of Nuneaton (R. D. Vernon).

South Wales Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: Darran Ddu Seam. *Locality:* Mynachdy Colliery, Old Ynysybwl, near Pontypridd, Glamorganshire (D. Davies).

Kent Coalfield.

ETRURIA MARL GROUP.

Horizon: At depths of 2684 to 2690 feet. *Locality:* Bere Farm Boring, 1¾ miles north-east of Dover (Collection of Geological Survey, London).

Horizon: At depths of 1980, 2950–2955, and 3095–3097 feet. *Locality:* Boring at Tower Brickworks, Folkestone (Collection of Geological Survey, London).

South Staffordshire Coalfield.

ETRURIA MARL GROUP.

Horizon: Old Hill Marls, within the upper 300 feet of the Group. *Locality:* Granville Pit, Old Hill Station, 1½ miles north-east of Halesowen.

Cumberland Coalfield.

BLACKBAND GROUP.

Horizon: "Whitehaven Sandstone." *Locality:* Top beds of Cliff Quarry, behind William Pit, Bransty (Collection of Geological Survey, London).

Lancashire Coalfield.

BLACKBAND GROUP.

Horizon: Strata between 24–213 feet above Bradford Four-foot Coal. *Locality:* Bradford Colliery, Manchester (W. Hemingway).

North Staffordshire Coalfield.

BLACKBAND GROUP.

Horizon: Four feet above Bassey Mine. *Locality:* Cobridge Marl Pit, near Cobridge Station.

Horizon: About horizon of Bassey Mine. *Locality:* Jackfield Colliery, near Hanley (A. Meigh).

Somerset and Bristol Coalfield.

BLACKBAND GROUP.

Horizon: Top Vein. *Locality:* Warmley, 5 miles east of Bristol, Gloucestershire.

South Wales Coalfield.

BLACKBAND GROUP.

Horizon: Hughes Vein (=No. 1 Rhondda Seam). *Locality:* Cwmburla, Swansea, Glamorganshire.

Horizon: No. 2 Rhondda Seam. *Localities:* Standard Collieries, Ynyshir, Glamorganshire (R. Weed); Pochin Pit, near Tredegar, Monmouthshire (=Pontygwaith Seam).

Horizon: Strata between Wenallt Seam and No. 2 Rhondda Seam. *Locality:* Glassbrooks Shaft, close to the village of Cadoxton, Glamorganshire (Collection of the Geological Survey, London).

Horizon: No. 3 Rhondda Seam. *Locality:* Glamorgan Colliery, Gilfach Goch, Glamorganshire (D. Davies).

WESTPHALIAN SERIES.

Ayrshire Coalfield.

Horizon: Below Red Shales, about position of Ell Coal. *Locality:* Burnockhill Pit, Ochiltree (J. Smith).

Douglas Coalfield.

Horizon: 40 fathoms from surface. *Locality:* Douglas No. 3 Boring, $\frac{1}{8}$ mile north-west of Weston and about 1 mile S.S.W. of Douglas, Lanarkshire (Collection of Geological Survey, Edinburgh).

Lanarkshire Coalfield.

Horizon: Forty to fifty feet below Upper Coal. *Locality:* Luggie Burn, 60 yards south of the Railway Viaduct, fully $\frac{3}{4}$ mile W.N.W. of Old Monkland Church (Collection of Geological Survey, Edinburgh).

Burnley Coalfield.

Horizon: Low Bottom Coal. *Locality:* Near Burnley (Museum, University, Manchester).

Horizon: Arley Mine. *Locality:* Brickwood, Hibson Road at Marsden Height, Nelson (P. Whalley).

Forest of Wyre Coalfield.

Horizon: Brooch Coal. *Localities:* Highley Colliery, Highley, Shropshire (Collection of Geological Survey, London); Kinlet Colliery, 1 mile south-west of Highley, Shropshire (Collection of Geological Survey, London).

Horizon : ?. *Localities :* Railway Cutting, 150 yards south-east of Northwood House, ½ mile north of Bewdley, Worcestershire (Collection of Geological Survey, London) ; Seckley Cliff, west bank of Severn, 450 yards south-west of Eymore Farm, ¾ mile south of Upper Arley, Worcestershire (Collection of Geological Survey, London); Roadside at back of building, Cooper's Hill, 1½ miles west of Dowles Church, near Bewdley, Worcestershire (Collection of Geological Survey, London).

Lancashire Coalfield.

Horizon : Bassey Mine. *Locality :* Linnyshaw Pit, Worsley (I. Ainsworth).

Horizon : "Forest Bed." *Locality :* Oldham Edge, Oldham (J. Nield).

Horizon : Peacock Mine. *Locality :* Bardsley Colliery, Ashton-under-Lyne (G. Wild).

Horizon : Quarter Mine. *Locality :* Coney Green, Radcliffe (J. Lomax).

Horizon : Trencher Bone Mine. *Locality :* Worsley.

Leicestershire and South Derbyshire Coalfield.

Horizon : Immediately above Block Coal (=Watson Coal). *Locality :* Stanton Colliery, Clay Pit, 2½ miles south-east of Burton-on-Trent, Derbyshire (R. D. Vernon).

North Staffordshire Coalfield.

Horizon : Peacock Marl. *Locality :* Oldfield Brickworks, Fenton (J. T. Stobbs).

Horizon : Shales over Peacock Marl. *Locality :* Longton.

Northumberland and Durham Coalfield.

Horizon : Crow Coal. *Locality :* Phœnix Brickworks, Crawcrook, Ryton, County of Durham (W. Eltringham).

North Derbyshire and Nottingham Coalfield.

Horizon : Below Top Hard Coal. *Locality :* Shipley Clay Pit, Ilkeston, Derbyshire (L. Moysey).

Horizon : Strata between Deep Hard Coal and Silkstone Coal. *Locality :* Bonds Main Colliery, near Chesterfield, Derbyshire (L. Moysey).

Horizon : Silkstone Coal. *Localities :* Bonds Main Colliery, near Chesterfield, Derbyshire (L. Moysey) ; Calow Colliery, Chesterfield, Derbyshire (L. Moysey).

Horizon : Immediately above Top Hard Coal. *Locality :* Brindsley Clay Pit, Langley Mill, 3 miles north of Ilkeston, Nottinghamshire.

Horizon : ?. *Locality :* Chesterfield (Chesterfield Museum).

South Staffordshire Coalfield.

Horizon : Immediately below Bottom Coal. *Locality :* Ruiton, near Sedgley.

Horizon : Blue Measures, 6 feet above Brooch Coal. *Locality :* Hamstead Colliery, Great Barr, 2½ miles south-east of Walsall (H. Insley).

Horizon: Brooch Coal. *Locality:* Oldbury.

Horizon: Six feet above Fire Clay Coal. *Locality:* Netherton Dudley (H. W. Hughes).

Horizon: Bed between Fireclay Coal and Bottom Coal. *Locality:* Netherton Dudley (H. W. Hughes).

Horizon: New Mine Coal. *Localities:* Coseley, near Dudley; Clattershall Colliery, Brettell Lane, 1½ miles north-east of Stourbridge (H. W. Hughes).

Horizon: Ten-foot Ironstone Measures. *Locality:* Clayscroft openwork, Coseley, near Dudley.

Horizon: Thick Coal. *Locality:* Bradley Colliery, Bilston, 2½ miles south-east of Wolverhampton.

Titterstone Clee Hill Coalfield.

Horizon: 153 feet below Four-foot Coal. *Locality:* Chimney Pit Boring, Angelbank, Titterstone Clee Hill, Shropshire.

Horizon: Great Coal. *Locality:* Deep Pit Mound, Clee Hill, cutting to Belfrey Quarry, 1907, Shropshire (E. E. L. Dixon).

Horizon: Some distance above Great Coal. *Locality:* Penny's Pit, near Collybrook Cottage, Knowbury, Shropshire (E. E. L. Dixon).

Horizon: Gutter Coal. *Localities:* Pit, near Winthills Wood, Knowbury, Shropshire (E. E. L. Dixon); Colbury, 350 yards north-east of St Paul's Church, Knowbury, Shropshire (E. E. L. Dixon).

Horizon: Probably roof of Gutter Coal, but may be from some distance above it. *Locality:* Crinoline Pit, Farden, Shropshire (E. E. L. Dixon).

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Localities:* East Gawber Colliery, near Barnsley (W. Hemingway); Monckton Main Colliery, near Barnsley (W. Hemingway); Woolley Colliery, near Barnsley (W. Hemingway); Eliecar, 5½ miles south-east of Barnsley (Artis, type of species); Lundhill Colliery, Wombwell, near Barnsley (W. Gelder); Cooper's Colliery, Worsborough Dale, 2½ miles S. of Barnsley (W. Gelder); Old Oaks Colliery, near Barnsley (W. Gelder); South Kirkby Colliery, near Pontefract (W. Hemingway).

Horizon: Beeston Bed Coal. *Locality:* Clay Pit, Clark Lane, Leeds (J. W. Bond).

Horizon: Old Hards Coal (=Parkgate Coal). *Locality:* Hartley Bank Colliery, Horbury (W. Hemingway).

Horizon: Rock below Haigh Moor Coal. *Locality:* Brightside, near Sheffield (W. Hemingway).

Horizon: Outcrop of Stanley Main Seam. *Locality:* Shale Quarry, Old Roundwood Colliery, 3 miles east of Wakefield (Stanley Nettleton).

Horizon: At depth of 540 feet from the surface. *Locality:* Rossington Main Colliery Sinking, 6 miles south of Doncaster (W. H. Dyson).

North Wales Coalfield.

Horizon: Five-foot Coal. *Locality:* Brynkinallt Colliery, nearly 1 mile north-east of Chirk Station, Denbighshire (Collection of Geological Survey, London).

Horizon: Two-yard Coal. *Locality:* Llay Hall Colliery, about 3 miles N.N.W. of Wrexham, Denbighshire (Collection of Geological Survey, London).

Horizon: Shales 33 yards above Yard Coal. *Locality:* Sinking at Cefn-y-Coed Colliery, near Pontybodkin, Flintshire (Collection of Geological Survey, London).

South Wales Coalfield.

Horizon: Four-foot Seam. *Locality:* Bwllfa Dare Colliery, Aberdare, Glamorganshire.

Horizon: Pentre Seam. *Locality:* Trane Colliery, Gilfach Goch, Glamorganshire (D. Davies).

Horizon: Seven-foot Seam. *Locality:* Ysguborwen Colliery, Aberdare, Glamorganshire.

Horizon: Two-foot Nine-inch Seam. *Locality:* Beaufort, Monmouthshire.

Horizon: Between Engine Coal and Old Man's Coal. *Locality:* Clydach, Glamorganshire.

Asterotheca crenulata Brongniart sp.

Plate CXIV, figs. 4, 4*a*, 4*b*; text-figs. 58, 59.

1828. *Pecopteris crenulata* Brongniart, "Prodrome," p. 57.
1832 or 1833. *Pecopteris crenulata* Brongniart, "Hist. des végét. foss.," p. 300, pl. lxxxvii, fig. 1.
1838. *Pecopteris crenulata* Sternberg, "Versuch," vol. ii, fasc. vii–viii, p. 146.
1886. *Pecopteris* (*Asterotheca*) *crenulata* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 192, pl. xxv, figs. 1–4.
1888. *Pecopteris crenulata* Kidston, "Foss. Flora Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 373.
1914. Cf. *Pecopteris crenulata* Arber, "Fossil Flora of the Kent Coalfields," *Quart. Journ. Geol. Soc.*, vol. lxx, p. 73, pl. xi, fig. 3.
1893. *Pecopteris crenulata* Potonié, "Flore d. Rothl. Thüringen," p. 65, pl. v, fig. 6; pl. vi, figs. 1, 3, 4 (*non* fig. 2).
1836. *Alethopteris crenulata* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 302.
1845. *Alethopteris crenulata* Unger, "Synop. plant. foss.," p. 81.
1874. *Alethopteris crenulata* Schimper, "Traité de paléont. végét.," vol. iii, p. 499.
1879. *Pseudopecopteris subcrenulata* Lesquereux, "Coal Flora," vol. i, p. 193, pl. xxxvii, figs. 7, 8 (*refs. in part*).

Description.—Frond probably very large. Main rachis not known. Tripinnate on the greater part of the frond; possibly the lower pinnæ are quadripinnate. Rachis of primary pinnæ 1·5 mm. to 6 mm. in breadth, with very fine irregular striæ and small scattered apiculi. Rachis of secondary pinnæ with a furrow on upper surface, 0·5 mm. to 1 mm. in breadth, and bearing more or less numerous spreading or erect stiff hairs 1 mm. in length, which when removed leave a small punctiform cicatricule.

Primary pinnæ oval-lanceolate, sometimes slightly narrowed at base, 4 cm. to 15 cm. in breadth in their middle region and gradually contracting into a point at the summit. Secondary pinnæ linear-lanceolate, alternate, often touching each other laterally, 4 cm. to 7 cm. in length in the middle region of the frond and 1 cm. to 2 cm. in breadth; upper pinnæ reduced to 20 mm. to 15 mm. in length with a breadth of 4 mm. to 6 mm.; in the basal region they attain a length of at least 10 cm. or 12 cm. and a width of 2·5 cm. or more.

Pinnules alternate, slightly oblique to rachis, more or less decurrent, sometimes free, somewhat convex, oblong, with blunt rounded apex; sides straight or slightly concave and slightly expanded at base, 2 mm. to 3 mm. in breadth and 5 mm. to 10 mm. in length, margins entire or slightly crenulate, provided at the base and on the two sides of the median vein, at least on their inferior surface, with some rigid hairs, 0·5 mm. to 1 mm. in length. As the pinnæ are traced towards the summit of the frond, the pinnules become more and more united to each other, and finally assume the form of pinnatifid pinnæ, while at the apex they are replaced by large crenulate, decurrent pinnules which are united to each other at the base. Towards the base of the frond, on the other hand, the pinnules become more strongly crenulate and take the form of pinnatifid tertiary pinnæ.

Nervation.—Median vein thick, straight, or decurrent, extending to near the apex of the pinnule where it frequently divides; lateral veinlets thin, departing from the median vein at an open angle, and usually divided only once, but in the large pinnæ-like pinnules at the apex of the primary pinnæ, the anterior arm again divides. In the crenulate pinnules the veinlets lie in the little furrows which form the crenulate margin of the limb.

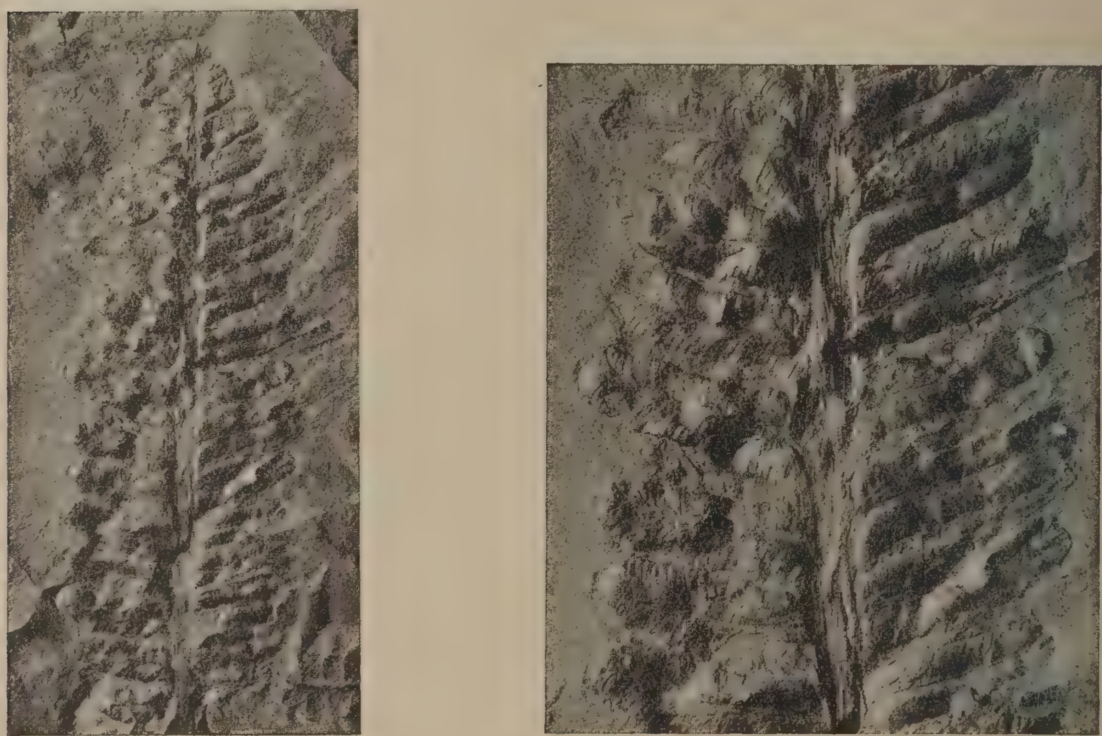
Fructification marginal. Sporangia coriaceous, ovoid, pointed at apex, 0·50 mm. to 0·75 mm. in length and 0·40 mm. in breadth, forming little star-like groups of four sporangia, and situated at the extremity of the lateral veinlets; synangia contiguous or slightly distant.

Remarks.—Very few examples of *Asterotheca crenulata* have been found in Britain. The most perfect specimen is that shown on Pl. CXIV, fig. 4, natural size. It shows a fragment of a primary pinna. The alternate secondary pinnæ are slightly contracted at their base, and the pinnules vary somewhat in their length; both of these features are seen on the figure given by Zeiller,* who confirmed the identification of our specimen. The pinnules are oblong, slightly expanded at base, in some cases free though closely placed to each other. The median vein is straight, springs from the rachis at almost right angles, and shows no decurrency. On a specimen of *Asterotheca crenulata* received from the late Professor Zeiller from the

* *Loc. cit.*, pl. xxv, fig. 2.

Mines of Bruay, Pas-de-Calais, some of the pinnules also seem to be free, and in these the median vein joins the rachis in a similar manner. In the upper pinnules of the same specimen, where they are united to each other and decurrent, the median vein is also distinctly decurrent. Whether therefore the median vein joins straight on to the rachis, or joins it in a decurrent manner, seems to depend on whether the pinnule is free or decurrent.

A part of a secondary pinna from our specimen is enlarged two and a half times



a *b*

Text-fig. 58.—*Asterotheca crenulata* Brongniart sp. *a*, Termination of a secondary pinna, natural size. *b*, Portion of the same enlarged two times. Specimen in the Collection of the Sedgwick Museum, Cambridge (No. 1051).

at fig. 4*a*, Pl. CXIV, to show the form of the pinnules, and the nervation is seen in the pinnule enlarged seven times at fig. 4*b*.

At text-fig. 58 (*a*), what is probably a secondary pinna from the apical portion of a frond or primary pinna is shown natural size. On this example the secondary pinnæ have assumed the form of elongated pinnules and the proximal fork of the veins usually dichotomizes, while the distal arm remains simple. A part of the specimen is enlarged two times at text-fig. 58 (*b*), to show the nervation. It was collected by Mr D. G. Lillie, and is preserved in the Sedgwick Museum, Cambridge (No. 1051). My thanks are due to the Curator for permission to figure it.

The synangia are marginal and seem to have only been borne on the central region of the secondary pinnæ. Their arrangement is seen at text-fig. 59, which is reproduced from Zeiller.

When one has well-preserved specimens which show the characters of the plant, *Asterotheca crenulata* can be easily distinguished from the other members of the genera *Asterotheca* and *Eupecopteris* by the nervation of the pinnules and, if fertile, by the arrangement and position of the synangia.

Through the kindness of Mr W. B. R. King, I have also been enabled to examine the specimens of *Asterotheca crenulata* recorded by the late Dr Arber from the Barfreston Boring (Kent) and those from the Boring at Mattice Hill, Sandwich (Kent). The specimens from the first-mentioned locality appear to be *Pecopteris crenulata* Brongniart, but those from Mattice Hill are very fragmentary, and are scarcely in a condition to admit of satisfactory identification.

Text-fig. 59.—*Asterotheca crenulata* Brongniart sp. Fertile pinnule enlarged two times. (After Zeiller.)

Distribution.—*Asterotheca crenulata* is very rare in Britain, and has been observed only at the undernoted localities.

RADSTOCKIAN SERIES.

RADSTOCK GROUP.

Horizon: ?. *Localities:* Camerton, 2 miles north of Radstock, Somerset; Norton Hill Pit, Midsomer Norton, 1½ miles west of Radstock, Somerset (R. Crookall).

STAFFORDIAN SERIES.

Somerset and Bristol Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: ?. *Localities:* Coal Pit Heath, near Bristol, Gloucestershire (Sedgwick Museum, Cambridge, No. 1051); Broad Oak Colliery, Pensford, 2 miles north of Clutton, Somersetshire (R. Crookall).

Kent Coalfield.

? NEWCASTLE-UNDER-LYME GROUP.

Horizon: At a depth of 2009 feet. *Localities:* Barfreston Boring, close to Barfreston Church, 6½ miles N.N.W. of Dover (Sedgwick Museum, Cambridge, E. A. N. Arber).

Asterotheca hemitelioides Brongniart sp.

Plate CXVII, figs. 1, 2, 2*a*, 4, and 5; text-fig. 60.

1833 or 1834. *Pecopteris hemitelioides* Brongniart, "Hist. des végét. foss.," p. 314, pl. cviii, figs. 1, 2.

1877. *Pecopteris hemitelioides* Grand'Eury, "Flore carb. du Départ. de la Loire," *Mém. Acad. Sci., Paris*, xxiv, no. 1, p. 70, pl. viii, fig. 9.

1883. *Pecopteris hemitelioides* Renault, "Cours. de bot. foss.," vol. iii, p. 110, pl. xvii, figs. 9–11.

1888. *Pecopteris* (*Asterotheca*) *hemitelioides* Zeiller, "Flore foss. terr. houil. de Commentry," pt. 1, *Bull. Soc. Ind. min.*, ser. 3, vol. iv, livr. 2, p. 133, pl. xi, figs. 6, 7.

1890. *Pecopteris* (*Asterotheca*) *hemitelioides* Zeiller, "Flore foss. bassin houil. et perm. d'Autun et d'Épinac," *Études Gîtes Min. France*, p. 50, pl. ixa, fig. 2.

1892. *Pecopteris* (*Asterotheca*) *hemitelioides* Zeiller, "Flore foss. bassin houil. et perm. de Brive," *Études Gîtes Min. France*, fasc. ii, p. 15, pl. iii, figs. 1–3.
1893. *Pecopteris hemitelioides* Potonié, "Flora d. Rothl. v. Thüringen," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft 9. Theil 2, p. 51, pl. v, fig. 7 (pl. vii, figs. 6, 7).
1893. *Pecopteris hemitelioides* Sterzel, "Flora d. Rothl. im Plauenschen Grunde bei Dresden," *Abhandl. Math.-Phys. Kl. k. Sächs. Gesellsch. Wissensch.*, Band xix, p. 21, pl. ii, figs. 1–3, 4, 4*a* and 4*b*.
1899. *Pecopteris hemitelioides* Potonié, "Lehrb. d. Pflanzenpal.," p. 107, fig. 94*b*, b^2.
1906. *Pecopteris* (*Asterotheca*) *hemitelioides* Zeiller, "Flore foss. bassin houil. et perm. de Blanzy et du Creusot," *Études Gîtes Min. France*, p. 38.
1892. *Pecopteris hemitelioides* Potonié, *Sitz. Gesellsch. Naturforsch. Freunde, Berlin*, p. 76, figs. 3, 4.
1923. *Pecopteris hemitelioides* Gothan, "Leitfossilien," p. 50, fig. 49.
1836. *Hemitelites cibotioides* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 330.
1838. *Partschia Brongniartii* Presl in Sternberg, "Versuch," ii, fasc. vii-viii, p. 116.
1838. *Steffensia hemitelioides* Presl in Sternberg, *ibid.*, p. 122.
1838. *Steffensia ? dubia* Presl in Sternberg, *ibid.*, p. 124.
1877. *Asterotheca hemitelioides* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 293 (187).
1879. *Asterotheca hemitelioides* Schimper in Zittel, "Handb. d. Palaeont.," Abth. 2, "Palaeophytologie," p. 90, fig. 65 (1, 2).
1883. *Scolecopteris hemitelioides* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Abth. 1, Band lxxxviii, p. 755 (123).
1885. *Scolecopteris hemitelioides* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 205.
1893. *Pecopteris Zeilleri* Sterzel, "Flora d. Rothl. im Plauenschen Grunde bei Dresden," *Abhandl. Math.-Phys. Kl. k. Sächs. Gesellsch. Wissensch.*, Band xix, p. 23, pl. ii, figs. 4B, 5, 6, 7, 7*a*, 8.
1893. *Pecopteris* (*Scolecopteris*) *subhemitelioides* Sterzel, *ibid.*, p. 28, pl. ii, fig. 9; pl. iii, figs. 1*a–f*, 2*a*.

Description.—Frond very large, tripinnate, main rachis 3 cm. or more in width, the surface bearing linear cicatricules. Primary pinnæ large, 10 cm. to 20 cm. in breadth, rachis 0·75 cm. at least in width. Secondary pinnæ alternate, slightly oblique to primary rachis, lanceolate, most usually of almost equal width till near the summit where they rapidly contract into a blunt point, more rarely of almost equal width for about two-thirds of their length, then gradually narrow and end in a blunt point. Free or touching laterally. Rachis straight, and bearing small scales.

Pinnules alternate, upright to rachis or very slightly oblique, sides parallel, bluntly rounded at apex, sometimes slightly contracted at base, free or touching each other laterally, two and a half to four times longer than broad, 6 mm. to 12 mm. in length and 2 mm. to 3 mm. in breadth, flat or slightly convex.

Median vein thick, straight, not decurrent at base, extending to near the apex of the pinnule; lateral veinlets given off at a slight angle, straight, sometimes feebly arcute, all simple.

Fertile and sterile pinnæ and pinnules similar in form. Sporangia coriaceous, ovoid, tapering to a point at the summit, 0·75 mm. to 1 mm. in length and 0·3 mm. to 0·4 mm. in breadth, forming stellate synangia of four or five sporangia. Synangia situated on the lateral veinlets about midway between the midvein and the margin and forming two rows, one on each side of the median vein and covering the whole under surface of the pinnule.

Remarks.—Of *Asterotheca hemitelioides* I have seen only a few specimens, all of them very fragmentary. That shown at fig. 1, Pl. CXVII, represents part of a primary pinna of which the rachis is 5 mm. in breadth. Its outer coaly surface has been removed and the surface now exposed is longitudinally striated. On another specimen (No. 3855) part of the outer surface of the rachis is preserved and bears many small apiculi. The secondary pinnæ spread out at almost right angles, but in all on this example only the basal portions are preserved. They slightly overlap at their margins, but on the other specimen, to which reference has been made above, the pinnæ are close but do not touch each other.

The pinnules are about 2 mm. in breadth and 8 mm. in length, alternate, closely placed to each other but not overlapping ; median vein thick in proportion to the breadth of the pinnule ; lateral veins undivided.

On this specimen the pinnules appear at first to have crenate margins. Such, however, is not the case, and the appearance is caused by a thickening of the ends of the veinlets. These have been described by Potonié * in this and other species as water pores or water stomata. They have sometimes been mistaken for sori or as indicating the position from which such have been removed.†

A part of a secondary pinna is given natural size at fig. 5, Pl. CXVII. The pinnules here are separated by a slight space, and the same is seen on the small fragment of a secondary pinna enlarged two times at fig. 4 to show the nervation. This specimen occurs on the back of the same little slab. The pinna (fig. 5) contracts more gradually to the apex than usually seen in this species, but is similar in this respect to the pinnæ on a specimen of *Asterotheca hemitelioides* figured by Zeiller.‡

Sterzel describes and figures very fine hairs on the surface of pinnules of *Asterotheca hemitelioides*, but they would probably be seen only on exceptionally well-preserved specimens. These small villose hairs seem to have decayed very easily or were shed, as they are often absent from the surface of the pinnules of other species which are known to possess them.§

Fragments of two fertile pinnæ are given at fig. 2 and a part of one of them is enlarged three times at fig. 2*a*. The synangia are immature but exhibit their arrangement in two rows, one on each side of the midrib. In a few of the synangia the individual sporangia can be observed.

The fructification of *Asterotheca hemitelioides* has been described by Grand-'Eury ‖ and Zeiller,¶ one of whose illustrations is reproduced at text-fig. 60. The sporangia are coriaceous and are said to be more so than in any other member

* "Lehrb. d. Pflanzenpal.," p. 107.

† See also Renault, "Court de botan. foss." ("Glandes aquifères"), pp. 130–136, pl. xxiii, 1883 ; Potonié, "Wasserspalten . . . Organe bei fossilen und recenten Farnarten," *Sitz.-Bericht. Gesellsch. naturforsch. Freunde, Berlin*, no. 7, p. 75, 1892 ; Potonié, "Flora Rothl. v. Thuringen" (*loc. cit.*), p. 51 ; Sterzel, "Flora d. Rothl. bei Dresden" (*loc. cit.*), p. 22.

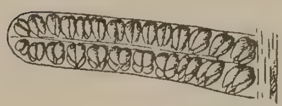
‡ "Bassin houil. et perm. de Brive," pl. iii, fig. 2.

§ Sterzel, *loc. cit.*, pl. ii, fig. 4B.

‖ "Flore carb. du Dép. de la Loire," *Mém. Acad. Sci., Paris*, xxiv, no. 1, p. 70, pl. viii, fig. 9.

¶ "Bassin houil. et perm. de Brive," fasc. 2, p. 18, pl. iii, figs. 1A and 3A.

of the group; the sporangia forming the synangia are supposed to be united to each other to a less extent. But in the specimens examined by ZEILLER, which confirm the description originally given by GRAND'EURY, the synangia had evidently attained to a mature condition. Might it not be, therefore, that the cause of the sporangia being free at the apex on his specimens was a preliminary to their separation before dehiscence?



TEXT-FIG. 60.—*Asterotheca hemitelioides* Brongniart sp. Fertile pinnule showing synangia. (After ZEILLER.)

Normally the synangia sit upright on the veins, but frequently they are found lying parallel to the surface of the pinnule. Our text-figure shows them occurring in both these positions, but the horizontal position is probably the result of accident.

In the form of the pinnules, *Asterotheca hemitelioides* has some resemblance to *Asterotheca Candolleana*, but the pinnules are more narrow in proportion to their length, are usually not contracted at base, and the rachises are apiculate or scaly. The lateral veinlets also seem to be invariably simple. In *Asterotheca cyathea* the rachises of various degrees are always smooth or have only fine longitudinal striations, and although the lateral veinlets are most frequently simple, a few that dichotomize can always be found. In dealing with well-preserved specimens, these two species are easily distinguished, but unfortunately the apiculi, on account of imperfect preservation, are sometimes not observable. The two species have, however, an individual character, which generally permits of their being easily separated from these allied species.

Asterotheca hemitelioides is easily distinguished from *Asterotheca lepidorachis* by its simple lateral veinlets, which in the latter are always dichotomous, and from *Pecopteris palacea* Zeiller * by the pinnules always showing a mixture of simple and divided lateral veinlets.

Distribution.—Asterotheca hemitelioides Brongniart sp. has been observed only in the Radstock Group of the Radstockian Series, and in the Newcastle-under-Lyme Group of the Staffordian Series, but in both horizons it is very rare.

RADSTOCK SERIES.

SOMERSET AND BRISTOL COALFIELD.

RADSTOCK GROUP.

Horizon: ?. *Localities:* Radstock, Somerset; Kilmersden Pit, near Radstock, Somerset; Upper Conygre Pit, Timsbury, 2½ miles N.N.W. of Radstock, Somerset; Camerton, 2 miles north of Radstock.

STAFFORDIAN SERIES.

NORTH STAFFORDSHIRE COALFIELD.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: ?. *Locality:* Railway Cutting, Florence Colliery, Longton.

* "Flore foss. terr. houil. de Commentry," pt. 1, p. 116, pl. xi, fig. 5; pl. xii, figs. 1, 2, 1888.

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PLATE XCII.

Dactylotheca plumosa Artis sp. forma *dentata* Brongniart pro sp.
Portion of a frond.
Locality.—Ludlow's Pit, Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 359.

R Kidston.

Zinco Collotype Co. Edinburgh

PLATE XCIII.

Fig. 1. *Dactylotheca plumosa* Artis sp.

Portion of a primary pinna.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Kidston Collection, No. 2101.

Fig. 1*a*. *Dactylotheca plumosa* Artis sp.

Two pinnules from upper pinnæ of same specimen, corresponding with those of *Filicites plumosus* Artis. Enlarged four times.

Figs. 1*b*–1*c*. *Dactylotheca plumosa* Artis sp.

Two pinnules from lower pinnæ of same specimen, corresponding with those of *Sphenopteris crenata* L. and H.

Enlarged four times.

Fig. 2. *Dactylotheca plumosa* Artis sp.

Portion of the main rachis of a frond, showing the aphlebiæ attached at the point of insertion of the pinnæ.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Kidston Collection, No. 1210.

Fig. 3. *Dactylotheca plumosa* Artis sp.

Some aphlebiæ (*Schizopteris adnascens* L. and H.).

Locality.—Near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Kidston Collection, No. 2110.

Fig. 4. *Dactylotheca plumosa* Artis sp.

Specimen showing the circinately-coiled pinnæ protected by the aphlebiæ.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Kidston Collection, No. 1212.

(All the specimens were collected by Mr W. Hemingway.)

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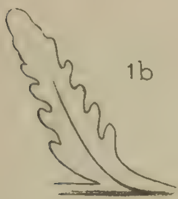
Palaeontology. Vol. II. 1924.

Plate XCIII.



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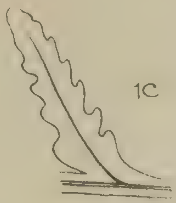

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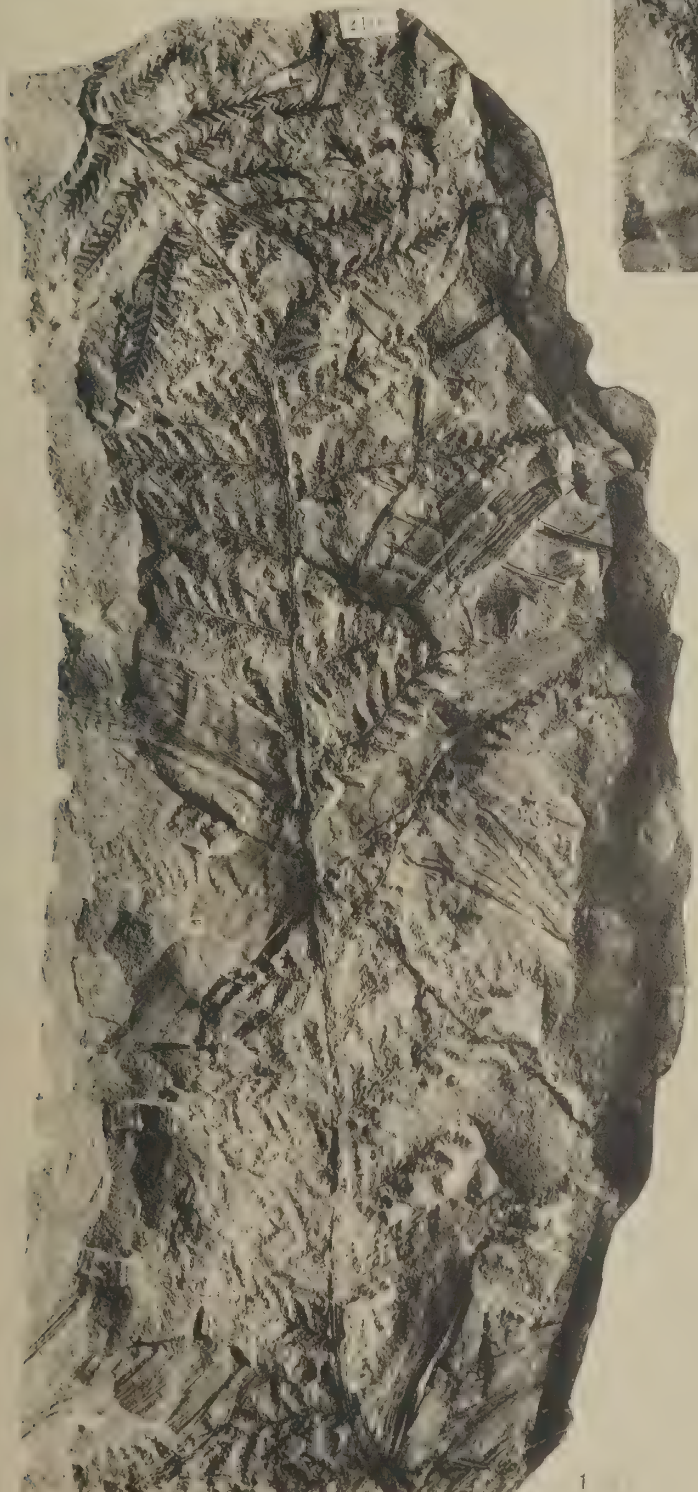

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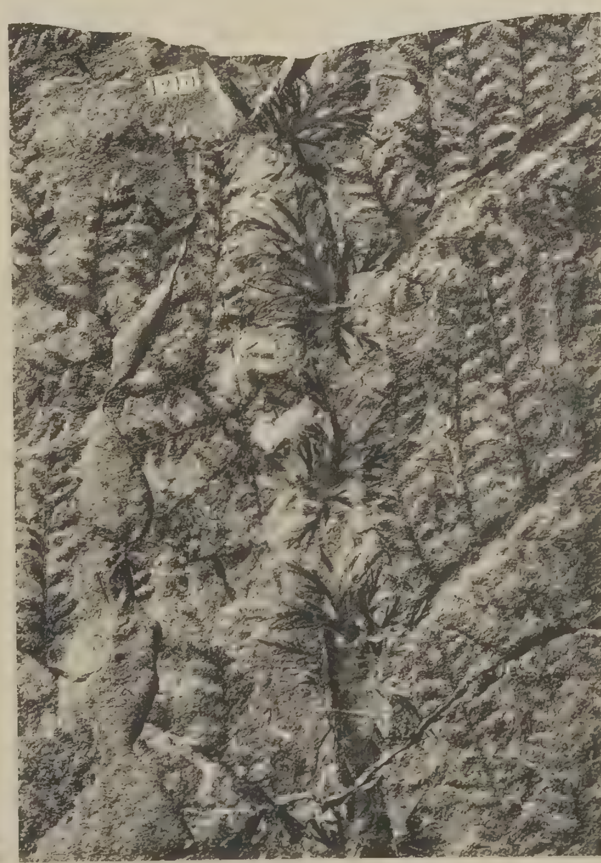

2

R. Kidston.

Zinco Collotype Co. Edinburgh

PLATE XCIV.

Fig. 1. *Dactylotheca plumosa* Artis sp.
Upper portion of a pinna.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 2107.

Fig. 1*a*. *Dactylotheca plumosa* Artis sp.
Two pinnules from last specimen, enlarged four times to show their form and nervation.

Fig. 2. *Dactylotheca plumosa* Artis sp.
Upper portion of a pinna.
Same locality and horizon. Collected by Mr W. Hemingway. Kidston Collection, No. 2112.

Figs. 2*a*, 2*b*. *Dactylotheca plumosa* Artis sp.
Two pinnules from last specimen, enlarged four times to show their form and nervation.

Fig. 3. *Dactylotheca plumosa* Artis sp.
Portions of probably primary pinnæ, corresponding with *Sphenopteris crenata* L. and H.
Locality.—South Kirby Colliery, near Pontefract, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 2109.

Figs. 3*a*, 3*b*. *Dactylotheca plumosa* Artis sp.
Two pinnules from last specimen, enlarged four times to show their form and crenulation of margins.

Fig. 4. *Dactylotheca Sturi* Sterzel pro var.
Fragment of a pinna.
Locality.—Shore near high-water mark at Cuthill, between Musselburgh and Prestonpans, Haddingtonshire.
Horizon.—Beds between No. 4 and No. 5 Limestones, Upper Limestone Group. Carboniferous Limestone Series.
Natural size. Kidston Collection, No. 4517.

Fig. 4*a*. *Dactylotheca Sturi* Sterzel pro var.
Some ultimate pinnæ from last specimen, enlarged two times.

Fig. 5. *Dactylotheca Sturi* Sterzel pro var.
Fragments of pinnæ, showing form of pinnules.
Same locality and horizon as previous specimen.
Natural size. Kidston Collection, No. 5421.

Fig. 6. *Dactylotheca Sturi* Sterzel pro var.
Main rachis, showing densely punctate surface.
Same locality and horizon as last.
Natural size. Kidston Collection, No. 5424.

MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

Palaeontology. Vol. II. 1924. Plate XCIV.

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PLATE XCV.

Fig. 1. *Dactylotheca plumosa* Artis sp.
Fragments of probably primary pinnæ.
Locality.—Shropshire.
Horizon.—?.
Natural size. Kidston Collection, No. 966.

Fig. 1*a*. *Dactylotheca plumosa* Artis sp.
Pinna from last specimen, enlarged four times to show segmentation.

Fig. 2. *Dactylotheca plumosa* Artis sp.
Portion of a fertile pinna, showing the sporangia.
Locality.—Woolley Colliery, Darton, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 1215.

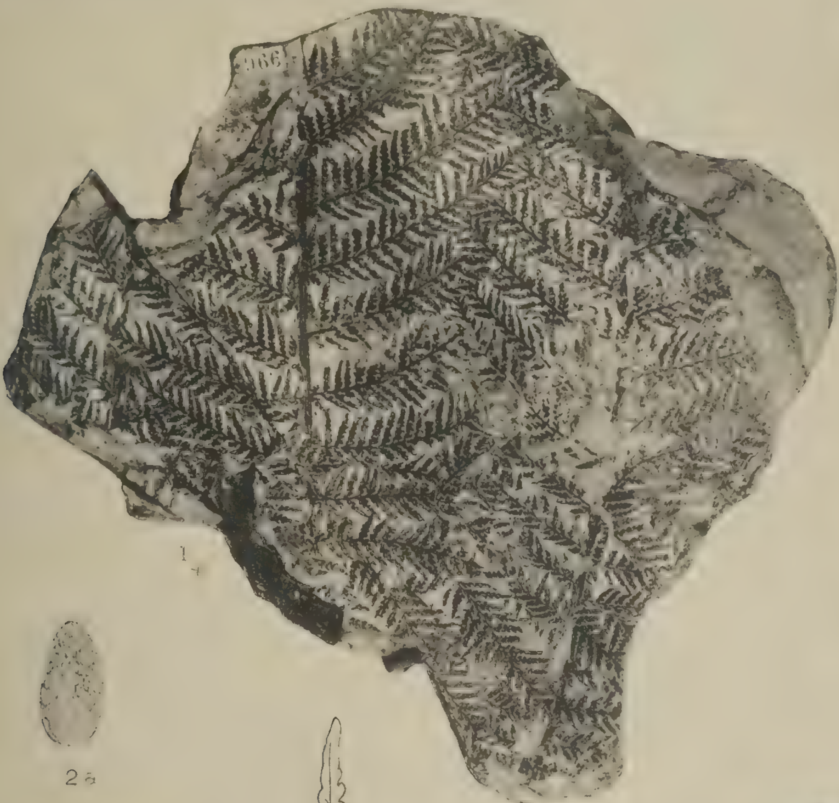
Fig. 2*a*. *Dactylotheca plumosa* Artis sp.
Sporangium from last specimen, enlarged twenty-six times.

Fig. 3. *Dactylotheca plumosa* Artis sp.
Sporangia enlarged twenty-eight times, from another specimen.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Collected by Mr W. HEMINGWAY. Kidston Collection, No. 2092.

Fig. 4. *Senftenbergia ophiodermatica* Göppert sp.
Portion of a fertile, probably primary pinna.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 2604.

Fig. 4*a*. *Senftenbergia ophiodermatica* Göppert sp.
Portion of last specimen, enlarged two times to show more distinctly the form of the pinnules.

Fig. 4*b*. *Senftenbergia ophiodermatica* Göppert sp.
Pinnule from same specimen, enlarged seven and a half times to show arrangement of sporangia.
From specimen seen at fig. 4.



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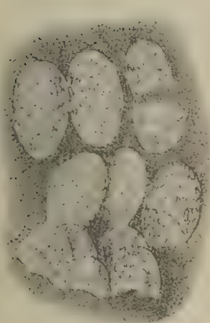

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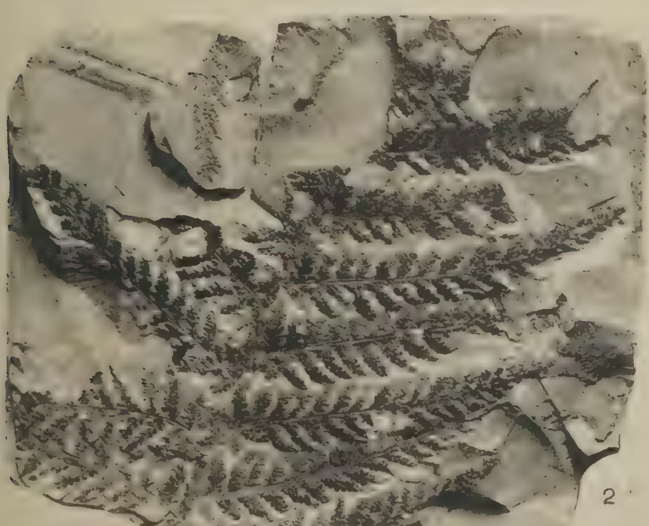

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PLATE XCVI.

Fig. 1. *Senftenbergia ophiodermatica* Göppert sp.
Parts of two fertile pinnæ.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 2088.

Figs. 1*a*, 1*b*. *Senftenbergia ophiodermatica* Göppert sp.
Pinnules from same specimen, enlarged eight times to show arrangement of the sporangia.

Fig. 2. *Dactylotheca plumosa* Artis sp. forma.
Fragment of probably a primary pinna.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 2111.

Fig. 2*a*. *Dactylotheca plumosa* Artis sp. forma.
Portion of ultimate pinna of last specimen, enlarged four times to show nervation and form of pinnules.

Fig. 2*b*. *Dactylotheca plumosa* Artis sp. forma.
Ultimate pinna from same specimen, enlarged three times to show segmentation and nervation.

Fig. 3. *Dactylotheca plumosa* Artis sp.
The form of the plant corresponding with *Sphenopteris caudata* L. and H.
Locality.—Adderley Green, near Longton, Staffordshire.
Horizon.—Below New Mine Coal. Westphalian Series.
Natural size. Collected by the late John Ward. Kidston Collection, No. 357.

Fig. 3*a*. *Dactylotheca plumosa* Artis sp.
Ultimate pinna from last specimen, enlarged four times to show segmentation.

Fig. 4. *Pecopteris Bioti* Brongniart.
Portion of probably a primary pinna.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 2245.

Fig. 4*a*. *Pecopteris Bioti* Brongniart.
Ultimate pinna from last specimen, enlarged three times to show segmentation.

Fig. 5. *Pecopteris ? hepaticæformis* Kidston.
Fragments of two pinnæ.
Locality.—? Coseley, near Dudley.
Horizon.—Ten-foot Ironstone Measures. Westphalian Series. (In the Collection of the late Sir Charles Holcroft.)

Fig. 5*a*. *Pecopteris ? hepaticæformis* Kidston.
Two pinnules from the same specimen, enlarged ten times.

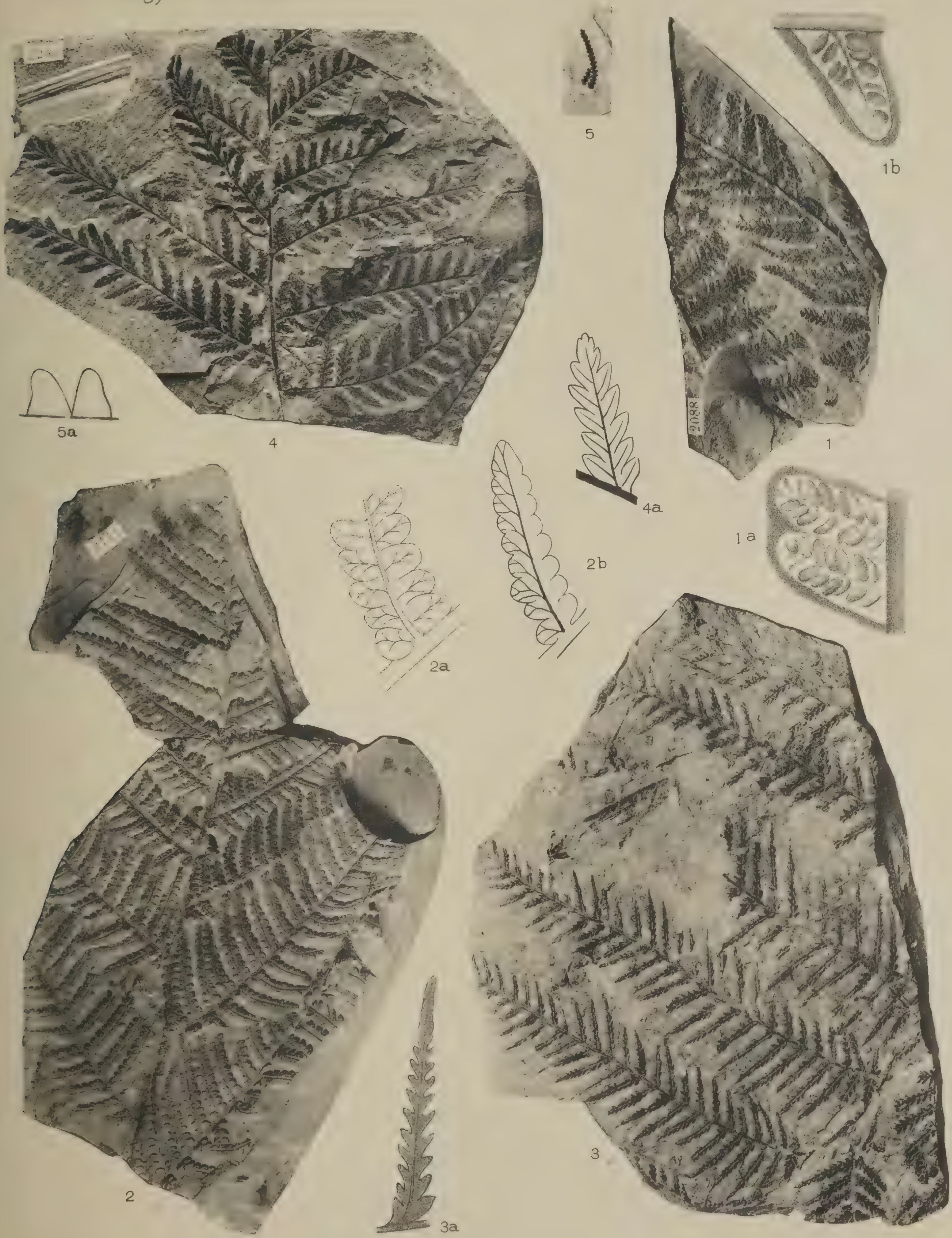

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PLATE XCVII.

Fig. 1. *Zeilleria hymenophylloides* Kidston.
Fragment of sterile pinna.
Locality.—Brickwork, Hibson Road at Marsden Height, Nelson, Lancashire.
Horizon.—Outcrop of Arley Mine. Westphalian Series.
Natural size. Collected by Mr Peter Whalley. Kidston Collection, No. 3439.

Fig. 1*a*. *Zeilleria hymenophylloides* Kidston.
Two pinnules from last specimen, enlarged six times to show their form and nervation.

Fig. 2. *Zeilleria hymenophylloides* Kidston.
Fragments of fertile pinnæ.
Same locality and horizon as last specimen.
Natural size. Collected by Mr Peter Whalley. Kidston Collection, No. 3695.

Fig. 2*a*. *Zeilleria hymenophylloides* Kidston.
Portion of a fertile pinnule from last specimen, enlarged nine times.

Fig. 3. *Zeilleria Frenzli* Stur sp.
Portion of a frond.
Locality.—Stanley Colliery, Liversedge, 6½ miles south-east of Bradford, Yorkshire.
Horizon.—Cannel Seam. Westphalian Series.
Natural size. Collected by Mr G. H. Knott. Kidston Collection, No. 5303.

Fig. 3*a*. *Zeilleria Frenzli* Stur sp.
Fertile pinnæ from last specimen, enlarged one and three-quarter times.

Fig. 3*b*. *Zeilleria Frenzli* Stur sp.
Fertile segment from same specimen, more highly enlarged.

Fig. 4. *Zeilleria delicatula* Sternberg sp.
Portion of a pinna.
Locality.—Claycross, Derbyshire.
Horizon.— ?. Westphalian Series.
Natural size. Collected by Mr E. Wilson. Kidston Collection, No. 204.

Fig. 4*a*. *Zeilleria delicatula* Sternberg sp.
Portion of last specimen, enlarged two times.

Fig. 4*b*. *Zeilleria delicatula* Sternberg sp.
Two basal ultimate pinnæ, enlarged six times to show the form of the pinnules.

Fig. 5. *Zeilleria delicatula* Sternberg sp.
Fragment of a frond.
Locality.—Claycross, Derbyshire.
Horizon.— ?. Westphalian Series.
Natural size. Collected by Dr L. Pegler. Kidston Collection, No. 205.

Fig. 5*a*. *Zeilleria delicatula* Sternberg sp.
Ultimate pinna from last specimen, enlarged three and a half times to show the form of the pinnules.

Fig. 6. *Zeilleria delicatula* Sternberg sp.
Fragments of fertile pinnæ.
Locality.—Forest of Wyre, Worcestershire.
Horizon.— ?. Westphalian Series.
Natural size. Specimen in the Geological Department of the British Museum.

Fig. 7. *Zeilleria delicatula* Sternberg sp.
A few fertile pinnules.
Same locality and horizon as last.
Natural size. Specimen in the Geological Department of the British Museum.

Fig. 7*a*. *Zeilleria delicatula* Sternberg sp.
The last specimen enlarged about two and a half times to show the form of the fructification.

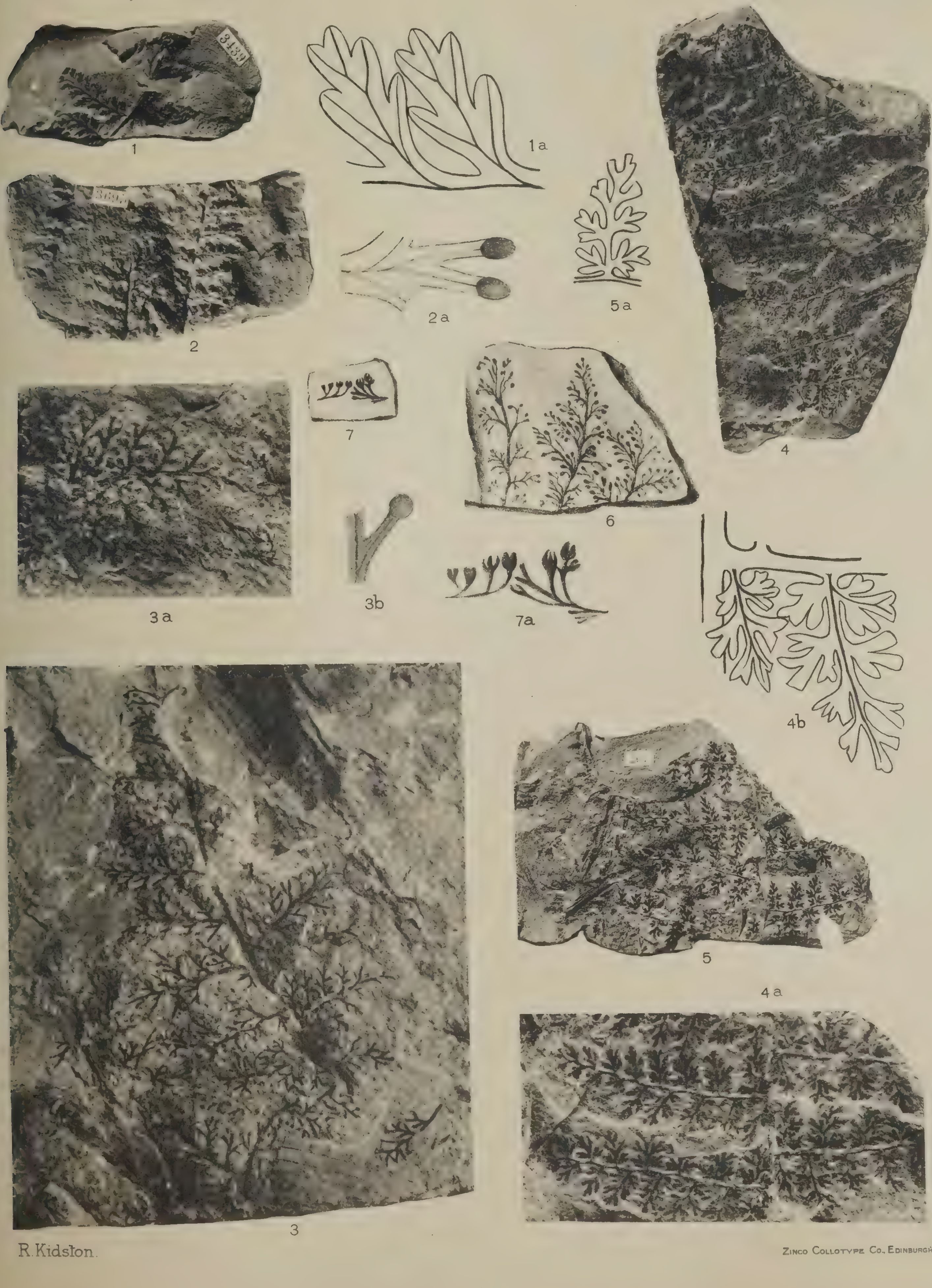

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PLATE XCVIII.

Fig. 1. *Zeilleria Avoldensis* Stur sp.
Portion of a primary pinna.
Locality.—Hamstead Colliery, Great Barr, 2½ miles south-east of Walsall, Staffordshire.
Horizon.—Above Brooch Coal. Westphalian Series.
Natural size. Collected by Mr Henry Insley. Kidston Collection, No. 4644.

Fig. 2. *Zeilleria Avoldensis* Stur sp.
Portion of a primary fertile pinna, bearing sporangia.
Locality.—Hamstead Colliery, Great Barr, 2½ miles south-east of Walsall, Staffordshire.
Horizon.—" Espley Band," Etruria Marl Group. Staffordian Series.
Natural size. Collection of Sedgwick Museum, Cambridge, No. 3390.

Fig. 2*a*. *Zeilleria Avoldensis* Stur sp.
Portion of last specimen, enlarged two times to show the sporangia more distinctly.

Fig. 3. *Zeilleria Avoldensis* Stur sp.
A macerated sporangium from the same specimen, showing the two sporangial masses *a*, *b*, contained within the sporangium. Enlarged 75 times.

Fig. 4. *Zeilleria Avoldensis* Stur sp.
Two spore masses, lettered *a* and *b*, from which the sporangial wall has been dissolved. Enlarged 75 times.

Fig. 5. *Zeilleria Avoldensis* Stur sp.
A single spore mass from the same specimen, removed from a sporangium to show its form. Enlarged 75 times.

Fig. 6. *Zeilleria Avoldensis* Stur sp.
Portion of a spore mass from the same specimen, enlarged 250 times to show the individual spores.

Fig. 7. *Cyclotheca biseriata* Kidston.
Spores enlarged 250 times to show their form. From specimen given on Pl. XCIX, fig. 4.

Fig. 8. *Zeilleria Avoldensis* Stur sp.
Portions of two ultimate pinnæ of specimen seen on Pl. XCIX, fig. 8, enlarged two times to show form and nervation of the pinnules.

Plate XCVIII.

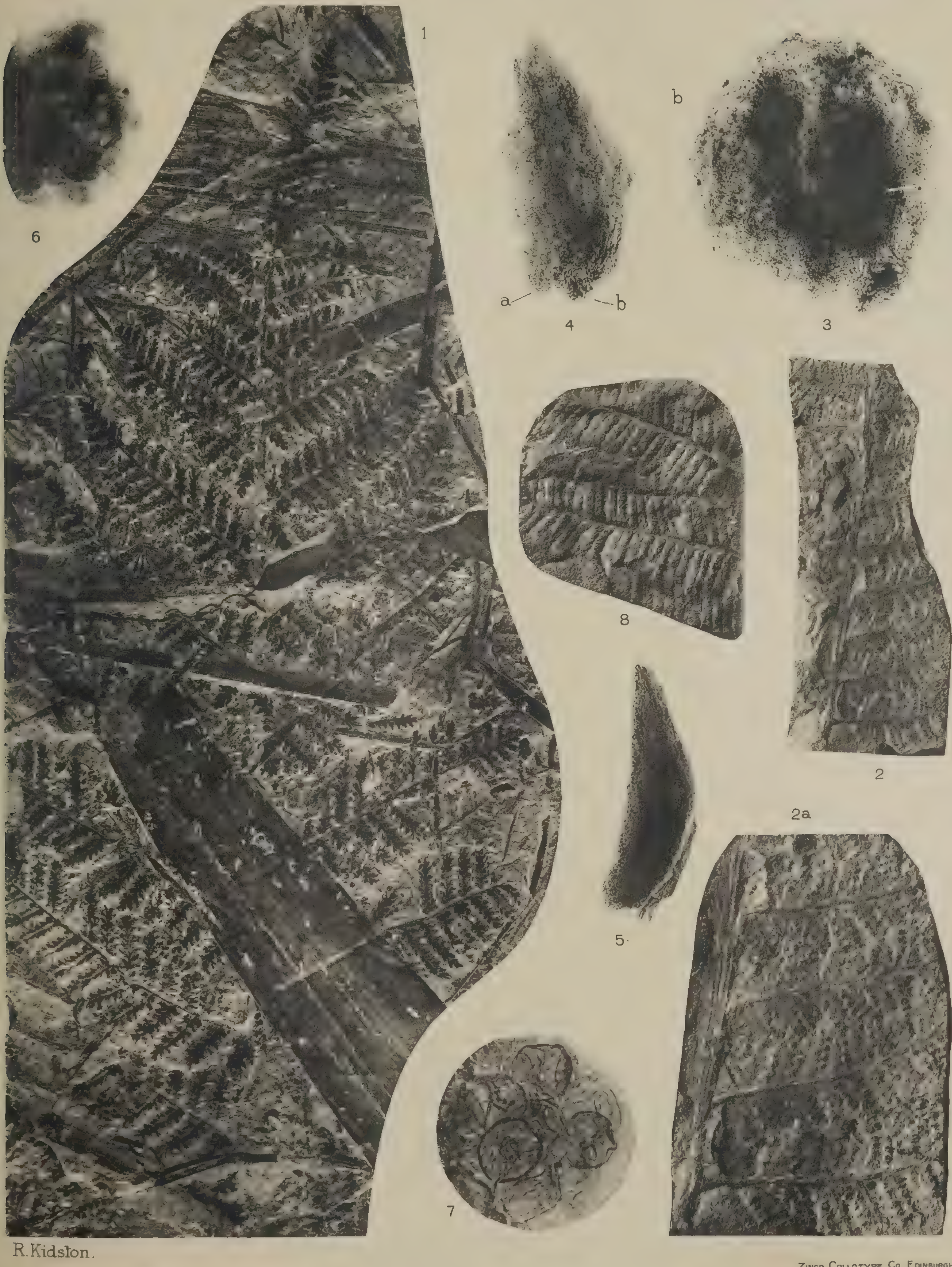

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PLATE XCIX.

Fig. 1. *Zeilleria Avoldensis* Stur sp.

Portion of a fertile specimen, showing the cupules.

Locality.—Clayscroft openwork, Coseley, near Dudley, South Staffordshire.

Horizon.—Ten-foot Ironstone Measures. Westphalian Series.

Enlarged two and a half times. Collection of Mr H. W. HUGHES.

Fig. 1*a*. *Zeilleria Avoldensis* Stur sp.

Cupule lettered *a* on fig. 1, enlarged two and a half times.

Fig. 2. *Zeilleria Avoldensis* Stur sp.

Portion of a fertile pinna showing the sporangia.

Locality.—Clayscroft openwork, Coseley, near Dudley, South Staffordshire.

Horizon.—Ten-foot Ironstone Measures. Westphalian Series.

Natural size. Collected by the late HENRY JOHNSON.

Figs. 2*a*, 2*b*. *Zeilleria Avoldensis* Stur sp.

Fertile pinnules from the same specimen, enlarged: *a*, showing the sporangium immature and closed; *b*, the sporangium mature and split into four valves.

Fig. 3. *Cyclotheca biseriata* Kidston.

Fragment of a pinna, showing the sporangia arranged on the pinnæ in two rows; one row on each side of the midrib.

Locality.—Ellismuir, Baillieston, Lanarkshire.

Horizon.—Kiltongue Coal. Lanarkian Series.

Natural size. "Dunlop Collection," Pittencrieff Museum, Dunfermline.

Figs. 4, 5. *Cyclotheca biseriata* Kidston.

Parts of fertile pinnæ.

Same locality and horizon as last.

Natural size. Collected by the late R. DUNLOP. Kidston Collection, fig. 4, No. 4614; fig. 5, No. 4615.

Fig. 5*a*. *Cyclotheca biseriata* Kidston.

Specimen given at fig. 5, enlarged two times.

Fig. 6. *Cyclotheca biseriata* Kidston.

Part of the two rows of sporangia of the specimen seen at fig. 5, enlarged twenty times to show their form and the cells of the sporangial wall.

Fig. 7. *Cyclotheca biseriata* Kidston.

Complete spore-contents of a sporangium, enlarged fifty times. From specimen No. 4614.

Fig. 8. *Zeilleria Avoldensis* Stur sp.

Portions of a sterile primary pinna.

Locality.—Britannic Collieries, Gilfach Goch, Glamorganshire.

Horizon.—Upper Yard Seam (=Bute Seam). Westphalian Series.

Natural size. Collected by Mr D. DAVIES. Kidston Collection, No. 5723.

Fig. 9. *Zeilleria hymenophylloides* Kidston.

Portion of a frond.

Locality.—Dolly Lane, Leeds.

Horizon.—Below Black Bed Coal. Westphalian Series.

Natural size. Collected by Mr J. W. BOND. Kidston Collection, No. 5876.

Fig. 10. *Zeilleria hymenophylloides* Kidston.

Portion of a frond.

Locality.—Brickwork, Hibson Road at Marsden Height, Nelson, Lancashire.

Horizon.—Outcrop of Arley Mine. Westphalian Series.

Natural size. Collected by Mr P. WHALLEY. Kidston Collection, No. 3421.

Fig. 10*a*. *Zeilleria hymenophylloides* Kidston.

Part of last specimen enlarged two times.

Fig. 11. *Zeilleria hymenophylloides* Kidston.

Ultimate pinna of specimen given on Pl. XCVII, fig. 1, enlarged two times.

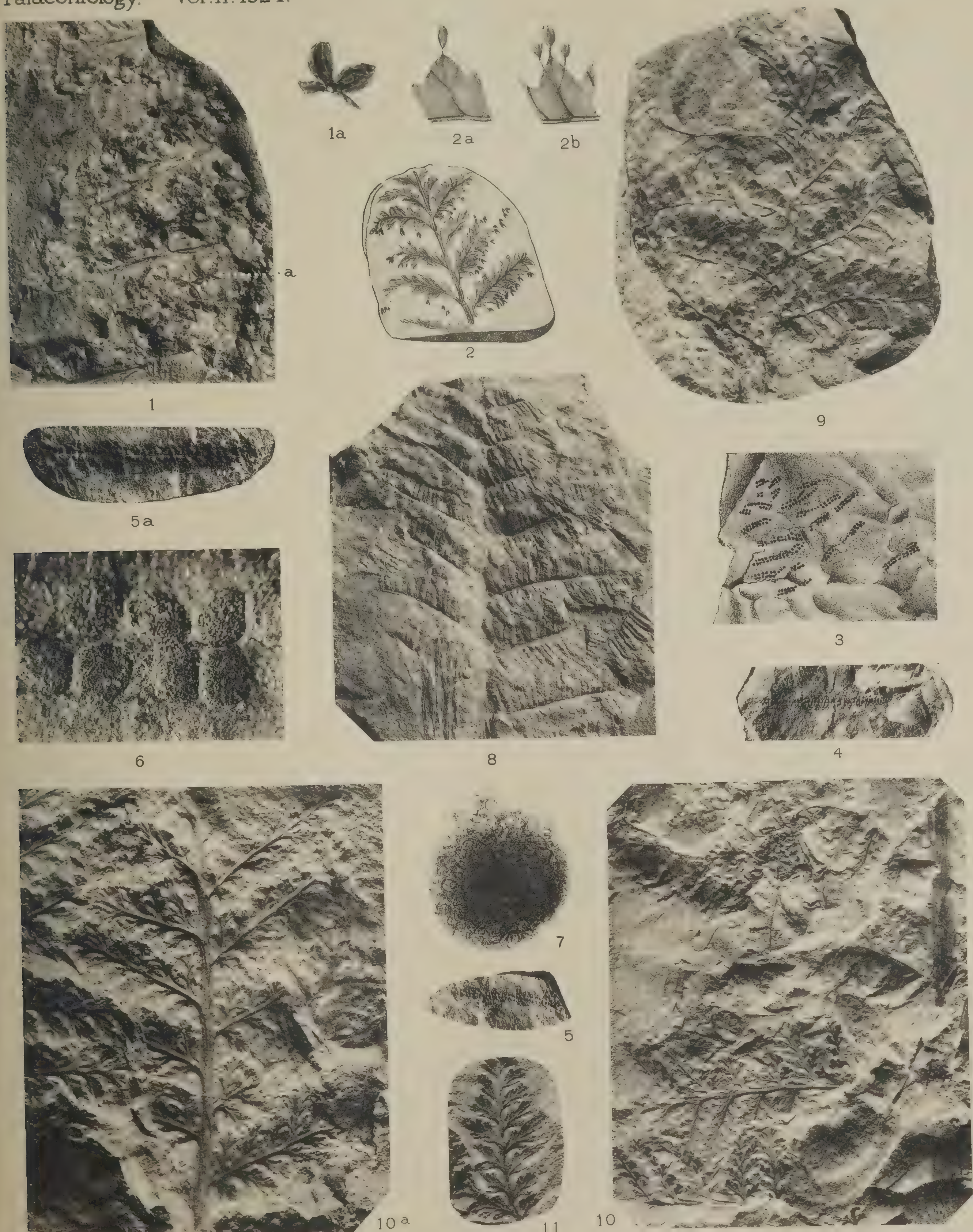

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PLATE C.

Fig. 1. *Telangium affine* Lindley and Hutton sp.

Portion of a frond, showing a dichotomy of the petiole which bears pinnæ below the fork.

Locality.—Hailes Quarry, Kingsknowe, Midlothian.

Horizon.—Wardie Shales. Oil-Shale Group. Calciferous Sandstone Series.

Natural size. Collected by the late D. Ritchie. Kidston Collection, No. 3742.

Fig. 2. *Telangium affine* Lindley and Hutton sp.

Portion of a frond, showing a dichotomy of the petiole and also a division of the two resulting forks.

Locality.—Burdiehouse, 4½ miles south of Edinburgh, Midlothian.

Horizon.—Burdiehouse Limestone. Oil-Shale Group. Calciferous Sandstone Series.

Natural size. Specimen in the "Hugh Miller Collection," Royal Scottish Museum, Edinburgh.

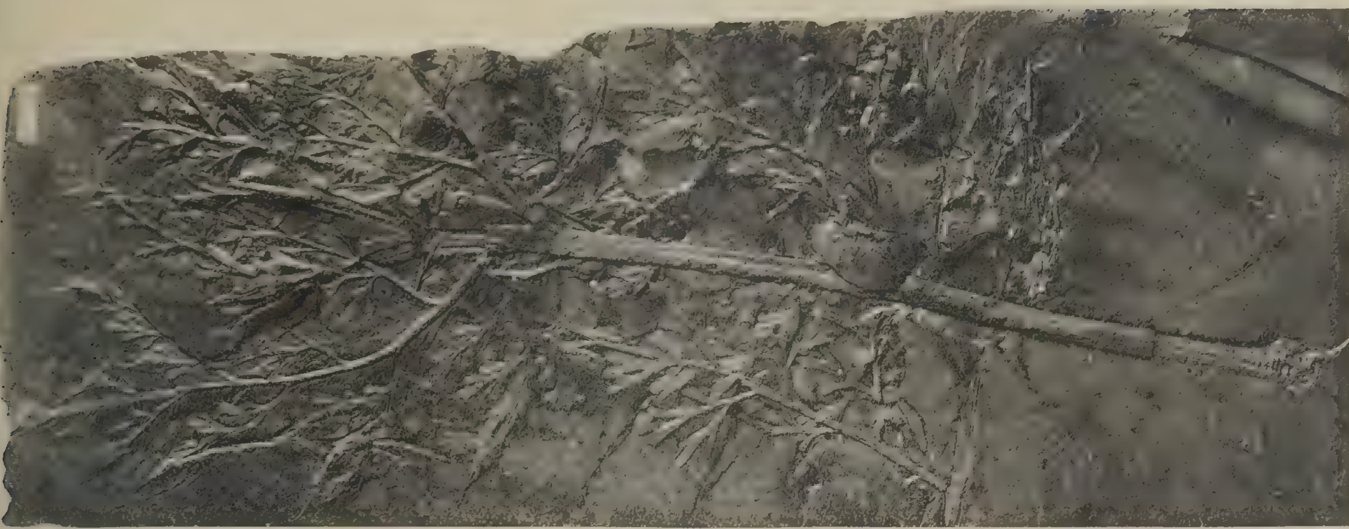
Fig. 3. *Telangium affine* Lindley and Hutton sp.

Spores taken from a sporangium on specimen No. 628, Kidston Collection, enlarged 275 times.

Locality.—West Calder, Midlothian.

Horizon.—Oil-Shale Group. Calciferous Sandstone Series.

Collected by the late C. W. Peach.



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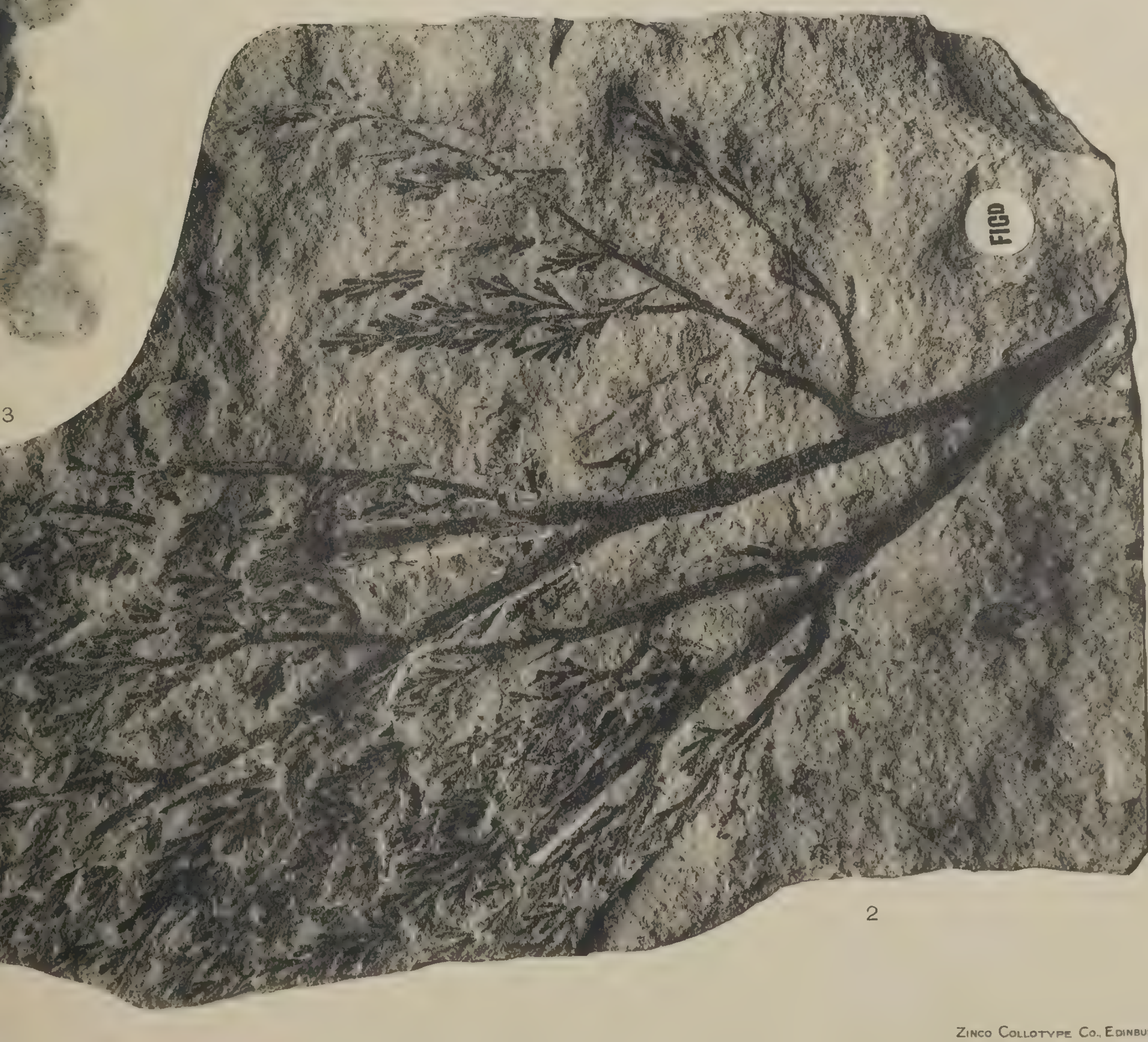

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PLATE CI.

Fig. 1. *Telangium affine* Lindley and Hutton sp.

Fertile specimen, showing the synangia terminating the ultimate divisions of the rachises.

Locality.—West Hermand, near West Calder, Midlothian.

Horizon.—Oil-Shale Group. Calciferous Sandstone Series.

Enlarged two times. Collected by the late C. W. Peach. Kidston Collection, No. 627.

Fig. 2. *Telangium affine* Lindley and Hutton sp.

Impression of a young frond, circinately coiled and showing the dichotomous division of the petiole into the two main segments of the frond.

Locality.—West Hermand, near West Calder, Midlothian.

Horizon.—Oil-Shale Group. Calciferous Sandstone Series.

Enlarged two times. Collected by the late C. W. Peach. Kidston Collection, No. 634.

Fig. 3. *Telangium affine* Lindley and Hutton sp.

Young frond circinately coiled and showing the two main divisions into which the frond divides.

Same locality and horizon as last.

Enlarged two times. Collected by the late C. W. Peach. Kidston Collection, No. 633.

Fig. 4. *Telangium affine* Lindley and Hutton sp.

Early state of development of probably one of the two sections of the frond on which the young pinnæ are circinately coiled.

Same locality and horizon.

Enlarged two times. Collected by the late C. W. Peach. Kidston Collection, No. 629.

Fig. 5. *Telangium affine* Lindley and Hutton sp.

An isolated synangium, showing four sporangia still preserved partially uncompressed.

Locality.—West Calder, Midlothian.

Horizon.—Oil-Shale Group. Calciferous Sandstone Series.

Enlarged four times. Collected by the late C. W. Peach. Kidston Collection, No. 648.

Fig. 6. *Telangium affine* Lindley and Hutton sp.

An ultimate pinna showing form of pinnules.

Locality.—Harwood Burn, below Limefield House, near West Calder, Midlothian.

Horizon.—Oil-Shale Group. Calciferous Sandstone Series.

Natural size. Collection of Geological Survey, Edinburgh.

Fig. 6*a*. *Telangium affine* Lindley and Hutton sp.

A pinnule from last specimen, enlarged two and a half times to show the nervation.

Fig. 7. *Telangium affine* Lindley and Hutton sp.

Fragment of a (?) primary pinna bearing very small pinnules. Removed from the matrix and mounted on glass.

Locality.—West Calder, Midlothian.

Horizon.—Oil-Shale Group. Calciferous Sandstone Series.

Natural size. Collected and prepared by the late C. W. Peach. Kidston Collection, No. 642.

Fig. 8. *Telangium affine* Lindley and Hutton sp.

Fragment of a primary pinna, bearing pinnules of the typical form. Removed from the matrix and mounted on glass.

Locality.—West Hermand, near West Calder, Midlothian.

Horizon.—Oil-Shale Group. Calciferous Sandstone Series.

Natural size. Collected and prepared by the late C. W. Peach. Kidston Collection, No. 644.

Fig. 9. *Telangium affine* Limdley and Hutton sp.

Fragment of a pinna with narrow pinnule-segments and showing a lax type of growth. Removed from the matrix and mounted on glass.

Locality.—West Calder, Midlothian.

Horizon.—Oil-Shale Group. Calciferous Sandstone Series.

Natural size. Collected and prepared by the late C. W. Peach. Kidston Collection, No. 641.

Fig. 10. *Telangium affine* Lindley and Hutton sp.

Fragment of a primary pinna, showing secondary pinnæ with narrow pinnules which spring from the rachis at a very acute angle. Removed from the matrix and mounted on glass.

Same locality and horizon as last.

Natural size. Collected and prepared by the late C. W. Peach. Kidston Collection, No. 643.


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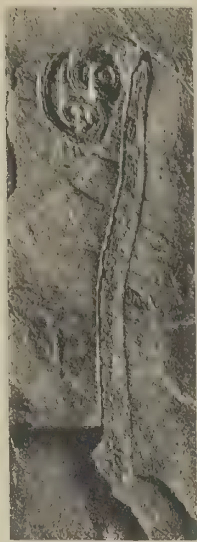
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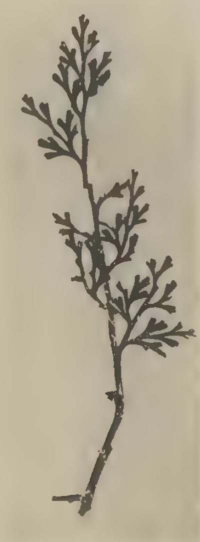
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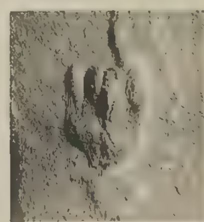
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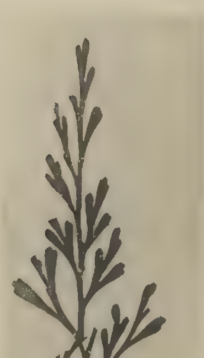
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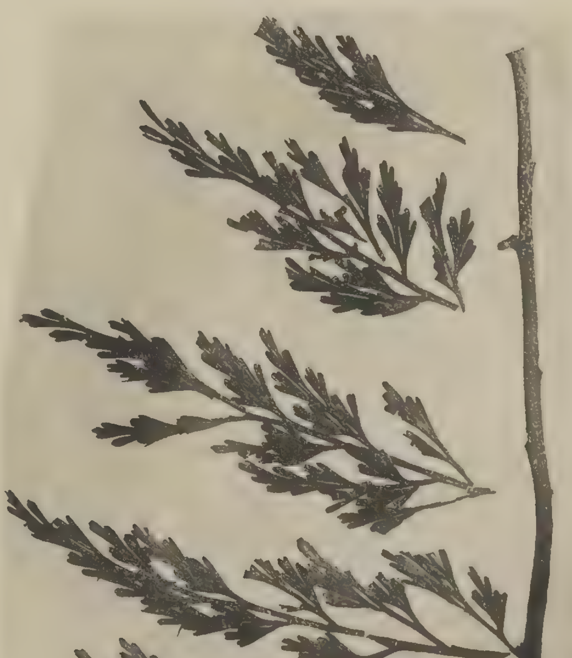
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PLATE CII.

Fig. 1. *Telangium affine* Lindley and Hutton sp.

Complete basal portion of a frond, showing the dichotomy of the petiole, below which a pair of pinnæ are borne.

Locality.—Burdiehouse, $4\frac{1}{2}$ miles south of Edinburgh, Midlothian.

Horizon.—Burdiehouse Limestone. Oil-Shale Group. Calciferous Sandstone Series.

Natural size. "Hugh Miller Collection," Royal Scottish Museum, Edinburgh.

Figs. 2, 3. *Telangium* (?) *Potieri* Zeiller sp.

Fragments of pinnæ.

Locality.—Bradford Colliery, Bradford, Manchester.

Horizon.—Shales lying from 8 feet to 107 feet above Bradford Four-foot Coal. Blackband Group. Staffordian Series.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, fig. 2, No. 3618; fig. 3, No. 3617.

Fig. 4. *Telangium* (?) *Potieri* Zeiller sp.

Fragment of a pinna.

Same locality and horizon.

Enlarged two times. Collected by Mr W. Hemingway. Kidston Collection, No. 3616.

Fig. 5. *Telangium bifidum* Lindley and Hutton sp.

Four synangia, spread out and seen from below.

Locality.—Glencartholm, River Esk, Eskdale, Dumfriesshire.

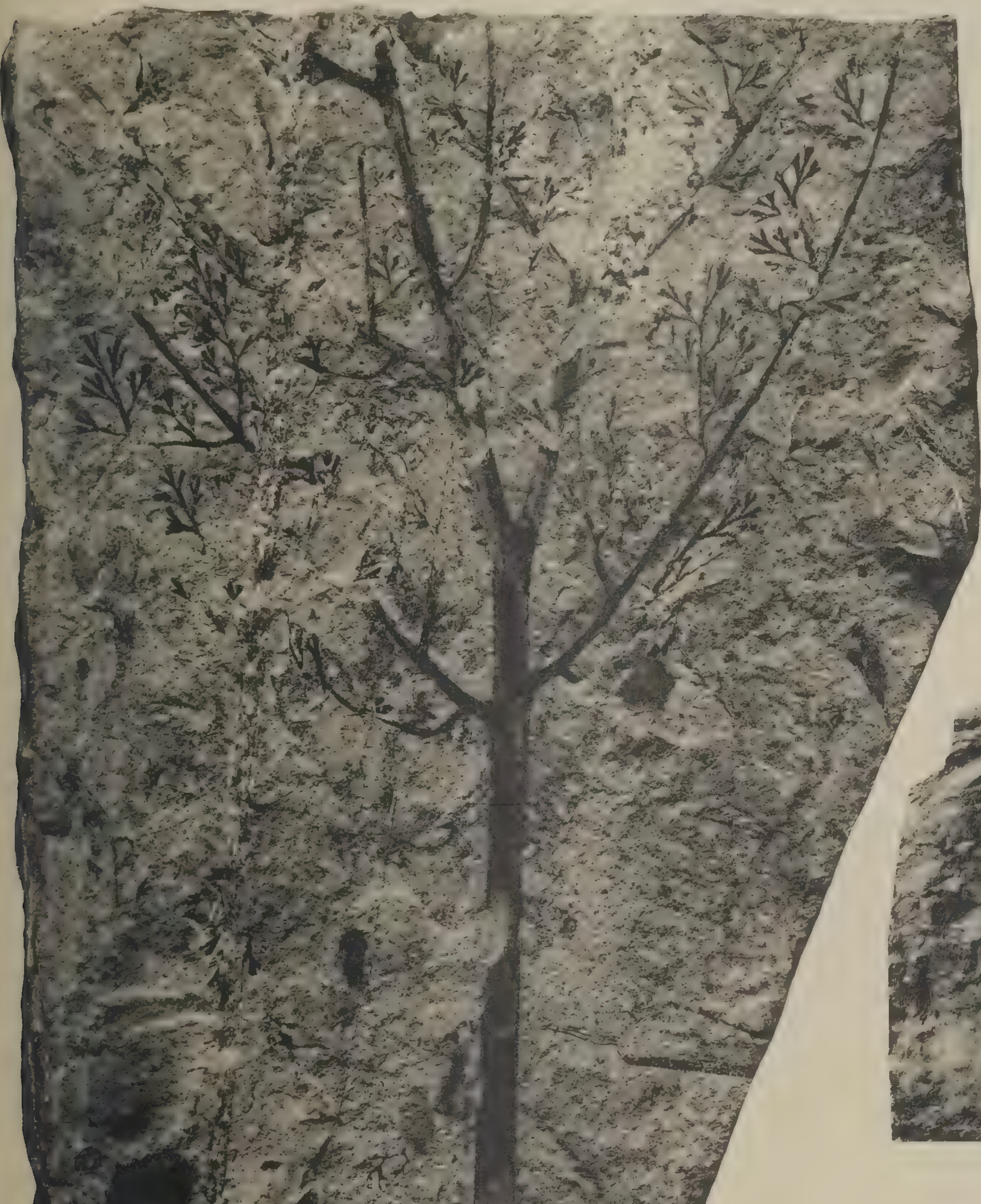
Horizon.—Base of Lawston and Muirburn Coals, correlated with Scremerston Coals.

Natural size.

Fig. 6. *Telangium bifidum* Lindley and Hutton sp.

Same specimen, enlarged about three and a half times to show the form of the disc and the sporangia.

Plate CII.



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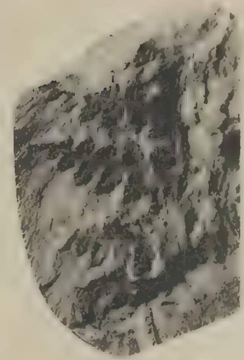

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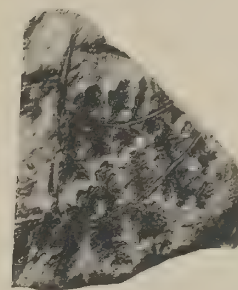

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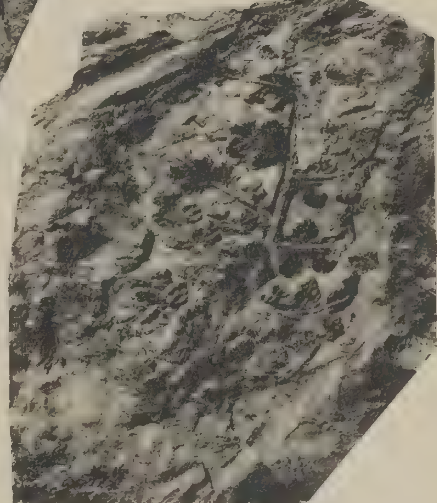

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PLATE CIII.

Fig. 1. *Telangium bifidum* Lindley and Hutton sp.
Part of one of the two segments into which the frond divides.
Locality.—Burdiehouse, 4½ miles south of Edinburgh, Midlothian.
Horizon.—Burdiehouse Limestone. Oil-Shale Group. Calciferous Sandstone Series.
Natural size. "Hugh Miller Collection," Royal Scottish Museum, Edinburgh.

Fig. 1*a*. *Telangium bifidum* Lindley and Hutton sp.
An upper pinna from the same specimen, enlarged.

Figs. 1*b*, 1*c*. *Telangium bifidum* Lindley and Hutton sp.
Two pinnules from same specimen, enlarged.

Fig. 2. *Telangium bifidum* Lindley and Hutton sp.
Basal portion of a petiole, bearing pinnæ below the bifurcation; seen at its upper end.
Locality.—Lewis Burn, about 200 yards below Lewis Burn Colliery, North Tynedale, Northumberland.
Horizon.—Lewis Burn Coal horizon, correlated with Scremerston Coals. Oil-Shale Group. Calciferous Sandstone Series.
Natural size. Kidston Collection, No. 728.

Fig. 3. *Telangium bifidum* Lindley and Hutton sp.
Fertile pinna, with synangia.
Same locality and horizon as last specimen.
Natural size. Collection of Geological Survey, London.

Fig. 4. *Telangium bifidum* Lindley and Hutton sp.
Group of synangia.
Locality.—Cranecleuch Burn, opposite Cranecleuch New Houses, Whickhope Burn, North Tynedale, Northumberland.
Horizon.—Top of Fells Sandstone. Calciferous Sandstone Series.
Natural size. Collection of Geological Survey, London.

Fig. 5. *Telangium bifidum* Lindley and Hutton sp.
A synangium and cupule.
Locality.—Lewis Burn, about 200 yards below Lewis Burn Colliery, North Tynedale, Northumberland.
Horizon.—Lewis Burn Coal horizon, correlated with Scremerston Coals. Oil-Shale Group. Calciferous Sandstone Series.
Natural size. Collection of Geological Survey, London.

Fig. 5*a*. *Telangium bifidum* Lindley and Hutton sp.
The cupule seen in fig. 5, enlarged three times.

Fig. 6. *Telangium bifidum* Lindley and Hutton sp.
Portion of slab, containing many shed synangia.
Same locality and horizon as last.
Natural size. Kidston Collection, No. 721.

Fig. 7. *Telangium bifidum* Lindley and Hutton sp.
Flattened cupules, showing the form of the segments into which they split.
Same locality and horizon.
Natural size. Kidston Collection, No. 723.

Fig. 8. *Telangium bifidum* Lindley and Hutton sp.
Complete spore-contents of two sporangia, enlarged twenty-five times.
Same locality and horizon.
From specimen shown at fig. 6.

Fig. 9. *Telangium bifidum* Lindley and Hutton sp.
Spores magnified 250 times.
Same locality and horizon.

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PLATE CIV.

Fig. 1. *Diplotheca stellata* Kidston.

An imperfect synangium on which only two of the sporangia are complete.

Locality.—Macrihanish Water, 320 yards west from Wimbledon Pit, near Campbeltown, Kintyre, Argyllshire.

Horizon.—Shale interbedded in sandstone. Limestone Coal Group. Carboniferous Limestone Series.

Natural size. Collection of Geological Survey, Edinburgh, No. M. 3172E.

Fig. 1*a*. *Diplotheca stellata* Kidston.

The same specimen, enlarged two times to show more clearly the form of the sporangia and their being united in pairs.

Fig. 2. *Diplotheca stellata* Kidston.

Two imperfect synangia, enlarged two times.

Same locality and horizon.

Collection of Geological Survey, Edinburgh, No. M. 3174E.

Fig. 3. *Unatheca oblonga* Kidston.

Portion of fertile pinna.

Locality.—Camerton, 2 miles north of Radstock, Somerset.

Horizon.—Radstock Group. Radstockian Series.

Natural size. Kidston Collection, No. 255.

Fig. 3*a*. *Unatheca oblonga* Kidston.

Two ultimate pinnæ of last specimen, enlarged three times.

Fig. 3*b*. *Unatheca oblonga* Kidston.

Single sporangium from same specimen, enlarged six times to show more clearly its structure.

Fig. 4. Fertile fragment of fern or fern-like plant allied to *Diplotmema Zeilleri* Stur.

Locality.—Old Mills Pit, Farrington Gurney, Somerset.

Horizon.—Farrington Group. Radstockian Series.

Natural size. Kidston Collection, No. 254.

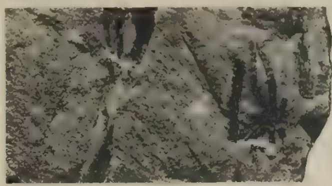
Fig. 5. *Telangium affine* Lindley and Hutton sp.

Part of the fertile specimen given on Pl. CI, fig. 1, enlarged five times to show the form of the synangia and their terminal position on the ultimate divisions of the frond.

Locality.—West Hermand, near West Calder, Midlothian.

Horizon.—Oil-Shale Group. Calciferous Sandstone Series. Kidston Collection, No. 627.

Plate CIV.



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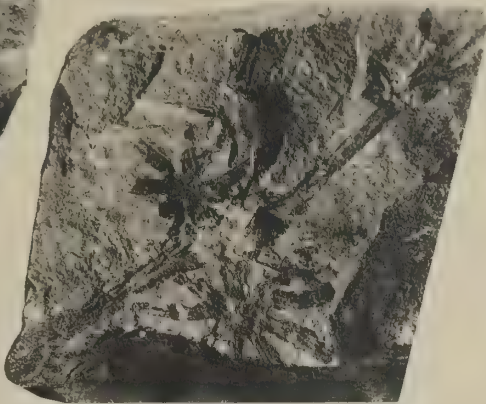

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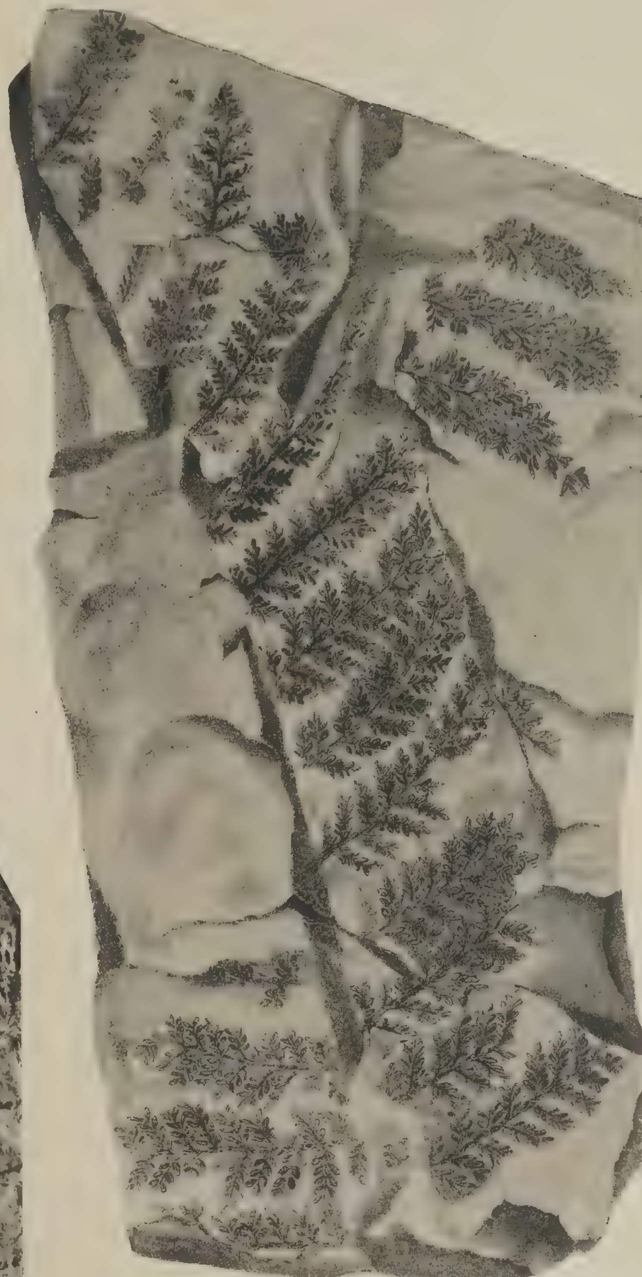

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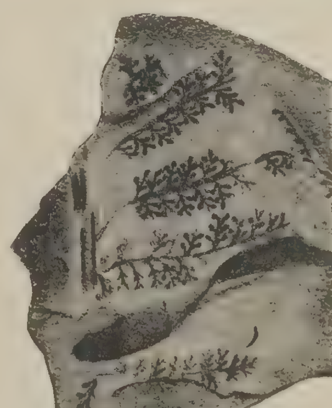

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PLATE CV.

Fig. 1. *Calymmatotheca Stangeri* Stur.

Stem giving off spirally-arranged petioles.

Locality.—Shaft sinking, Robroyston Colliery, $1\frac{3}{4}$ miles south-east of Bishopbriggs, Lanarkshire.

Horizon.—About 35 feet below Orchard Limestone. Upper Limestone Group. Carboniferous Limestone Series.

Natural size. Kidston Collection, No. 5592.

Fig. 2. *Calymmatotheca Stangeri* Stur.

Portion of a stem, enlarged two times to show the mesh-like reticulations formed by anastomozing sclerenchymatous bands.

Same locality and horizon. Kidston Collection, No. 5606.

Fig. 3. *Calymmatotheca Stangeri* Stur.

Termination of a pinna ending in a " clasper."

Same locality and horizon.

Natural size. Kidston Collection, No. 5593.

Fig. 4. *Calymmatotheca Stangeri* Stur.

Portion of a pinna, showing a dichotomy of the rachis. The form of the species named *Calymmatotheca Rothschildi* by Stur.

Same locality and horizon.

Natural size. Kidston Collection, No. 5607.

Fig. 5. *Calymmatotheca Stangeri* Stur.

Small fragment of a penultimate pinna.

Same locality and horizon.

Natural size. Kidston Collection, No. 5619.

Fig. 6. *Calymmatotheca Stangeri* Stur.

Ultimate pinnæ, bearing pinnules with small rounded lobes.

Same locality and horizon.

Natural size. Kidston Collection, No. 5605.

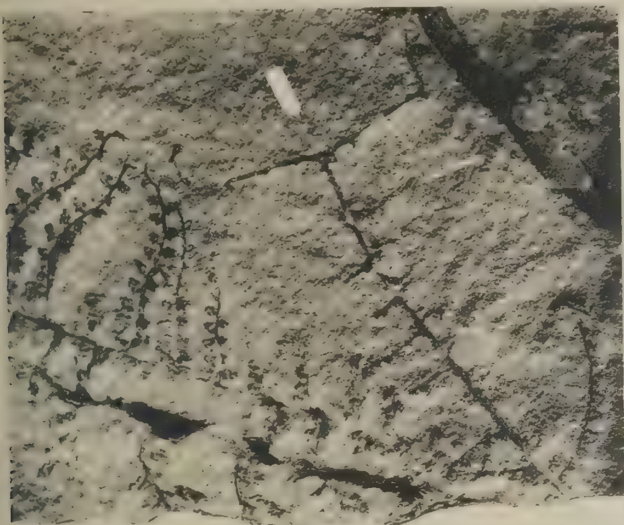
Fig. 7. *Calymmatotheca Stangeri* Stur.

Fragment of a frond, showing the form of the species named *Calymmotheca Schlehani* by Stur.

Locality.—New Braidbar Quarry, Giffnock, Renfrewshire.

Horizon.—Immediately below the Orchard Limestone. Upper Limestone Group. Carboniferous Limestone Series.

Natural size. Kidston Collection, No. 2422.



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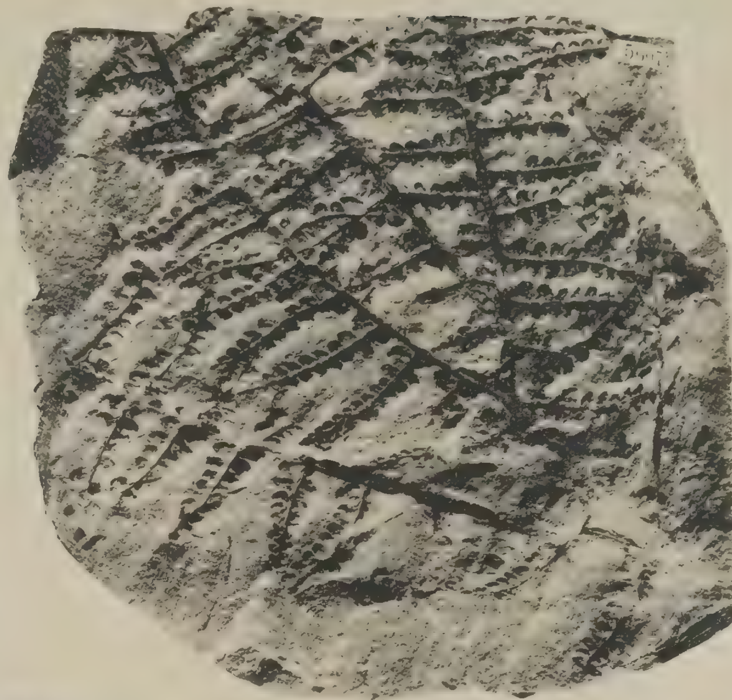

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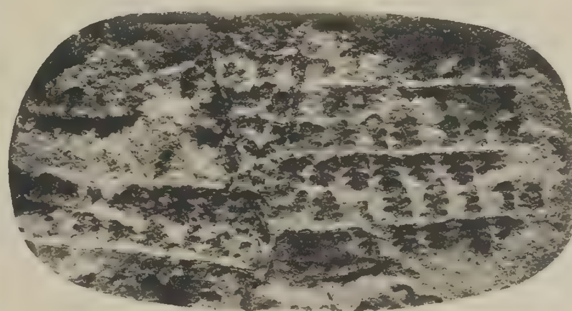

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PLATE CVI.

Fig. 1. *Calymmatotheca Stangeri* Stur.

Portions of two pinnæ; that on the left shows a dichotomy of the rachis. The specimen to the right is *Calymmotheca Rothschildi* Stur.

Locality.—Shaft sinking, Robroyston Colliery, $1\frac{3}{4}$ miles south-east of Bishopbriggs, Lanarkshire.

Horizon.—About 35 feet below Orchard Limestone. Upper Limestone Group. Carboniferous Limestone Series.

Natural size. Kidston Collection, No. 5601.

Fig. 2. *Calymmatotheca Stangeri* Stur.

Fragment of a primary pinna.

Same locality and horizon.

Natural size. Kidston Collection, No. 5611.

Fig. 3. *Calymmatotheca Stangeri* Stur.

Pinna showing a dichotomy. This form of the species is *Calymmotheca Schlehani* Stur.

Same locality and horizon.

Natural size. Kidston Collection, No. 5612.

Fig. 4. *Calymmatotheca Stangeri* Stur.

Ultimate pinna with large pinnules.

Locality.—New Braidbar Quarry, Giffnock, Renfrewshire.

Horizon.—Immediately below the Orchard Limestone. Upper Limestone Group. Carboniferous Limestone Series.

Natural size. Kidston Collection, No. 2565.

Fig. 5. *Calymmatotheca Stangeri* Stur.

Two ultimate pinnæ, enlarged two times to show form of pinnules and nervation.

Same locality and horizon as last.

Kidston Collection, No. 2564.

Fig. 6. *Calymmatotheca Stangeri* Stur.

Parts of two penultimate pinnæ, corresponding with *Sphenopteris Schlehani* Stur sp. as figured by GOTHAN.

Locality.—Caar Water, Dalry, in bank of stream 290 yards down from Drumastle Mill, Ayrshire.

Horizon.—Lower portion of "Millhouse Grit." Upper Limestone Group. Carboniferous Limestone Series.

Natural size. Collection of Geological Survey, Edinburgh, No. M. 2199F.

Fig. 7. *Calymmatotheca Stangeri* Stur.

Fragments of penultimate pinnæ.

Same locality and horizon as last.

Natural size. Collection of Geological Survey, Edinburgh, No. M. 2196F.

Fig. 8. *Calymmatotheca Stangeri* Stur.

Fragments of penultimate pinnæ.

Same locality and horizon.

Natural size. Collection of Geological Survey, Edinburgh, No. M. 2193F.

Fig. 9. *Calymmatotheca Stangeri* Stur.

Rachis of primary pinna, enlarged two times to show spine-like appendages.

Locality.—Shaft sinking, Robroyston Colliery, $1\frac{3}{4}$ miles south-east of Bishopbriggs, Lanarkshire.

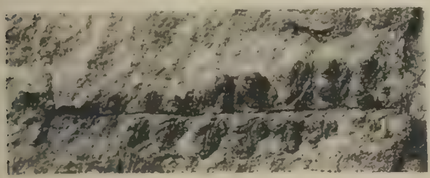
Horizon.—About 35 feet below Orchard Limestone. Upper Limestone Group. Carboniferous Limestone Series.

Kidston Collection, No. 5609.

MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

Palaeontology. Vol. II. 1924.

Plate CVI.



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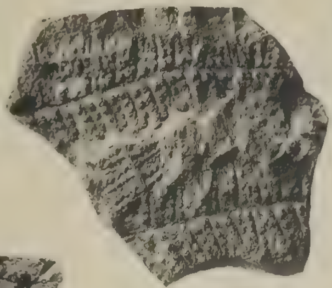

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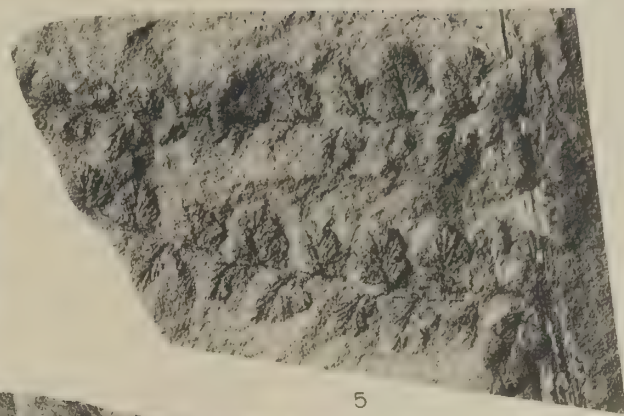

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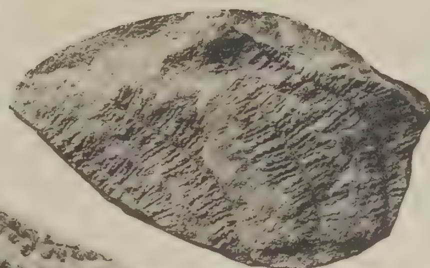

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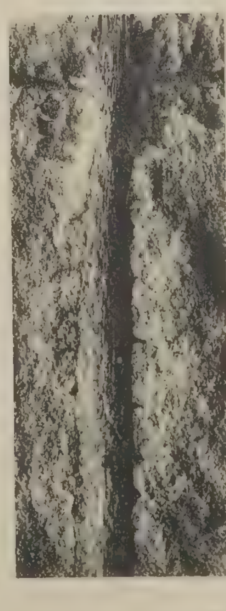

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PLATE CVII.

Fig. 1. *Calymmatotheca Stangeri* Stur.

Fragment of a penultimate pinna.

Locality.—Shaft sinking, Robroyston Colliery, $1\frac{3}{4}$ miles south-east of Bishopbriggs, Lanarkshire.

Horizon.—About 35 feet below Orchard Limestone. Upper Limestone Group. Carboniferous Limestone Series.

Natural size. Kidston Collection, No. 5604.

Fig. 1*a*. *Calymmatotheca Stangeri* Stur.

Ultimate pinnæ from same specimen, enlarged two times to show the form of the pinnules.

Fig. 2. *Calymmatotheca Stangeri* Stur.

Fragment of a frond associated with small *Carpolithes* seeds.

Locality.—Caar Water, Dalry, in bank of stream 290 yards down from Drumastle Mill, Ayrshire.

Horizon.—" Lower portion of Millstone Grit." Upper Limestone Group. Carboniferous Limestone Series.

Enlarged two times. Collection of Geological Survey, Edinburgh, No. M. 2185F.

Figs. 3–5. *Calymmatotheca Stangeri* Stur.

Portions of penultimate pinnæ from specimens shown on Pl. CVI, figs. 6–8, enlarged two times to show form of the pinnæ and pinnules.

Same locality and horizon as last.

Collection of Geological Survey, Edinburgh, Nos. M. 2199F, M. 2196F, M. 2193F.

Fig. 6. *Calymmatotheca Stangeri* Stur.

Pinnules enlarged three times to show their form.

Locality.—New Braidbar Quarry, Giffnock, Renfrewshire.

Horizon.—Immediately underneath the Orchard Limestone. Upper Limestone Group. Carboniferous Limestone Series.

Kidston Collection, No. 5565.

Fig. 7. *Schuetzia Bennieana* Kidston.

Axis showing three synangia, below which are seen the positions from which others have been removed.

Locality.—Water of Leith, opposite Kate's Mill, near Colinton, Midlothian.

Horizon.—Wardie Shales. Oil-Shale Group. Calciferous Sandstone Series.

Natural size. Kidston Collection, No. 2010.

Fig. 8. *Schuetzia Bennieana* Kidston.

Portion of an axis to which several synangia are attached.

Locality.—Railway Cutting between Boag's Mill and Kate's Mill, near Colinton, Midlothian.

Horizon.—Wardie Shales. Oil-Shale Group. Calciferous Sandstone Series.

Natural size. Collection of Geological Survey, Edinburgh, No. B. 1277A.

Fig. 8*a*. *Schuetzia Bennieana* Kidston.

The same specimen, enlarged two times to show the form of the synangia and microsporangia.

Fig. 9. *Schuetzia* cf. *Bennieana* Kidston.

Sporangial portions of synangia, enlarged two times.

Locality.—Bilston Burn, above junction with Dryden Burn, near Polton, Midlothian.

Horizon.—First coal above junction with Dryden Burn. Basal beds of " Millstone Grit." Upper Limestone Group. Carboniferous Limestone Series.

Kidston Collection, No. 161.

Fig. 10. *Schuetzia* cf. *Bennieana* Kidston.

Isolated microsporangia, enlarged two times.

Same locality and horizon.

Kidston Collection, No. 161.

Figs. 11, 12. *Schuetzia* cf. *Bennieana* Kidston.

The contents of two microsporangia in which the spores are united and form a columnar mass.

Same locality and horizon.

Enlarged seven times. Kidston Collection.

Fig. 13. *Schuetzia* cf. *Bennieana* Kidston.

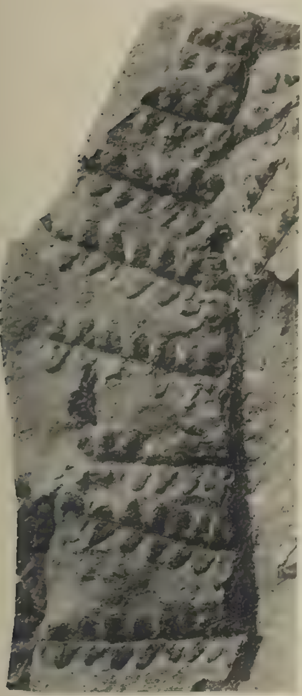
Spores enlarged, some showing the triradiate ridge.

Same locality and horizon.

Kidston Collection.

MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

Palaeontology. Vol. II. 1924. Plate CVII.



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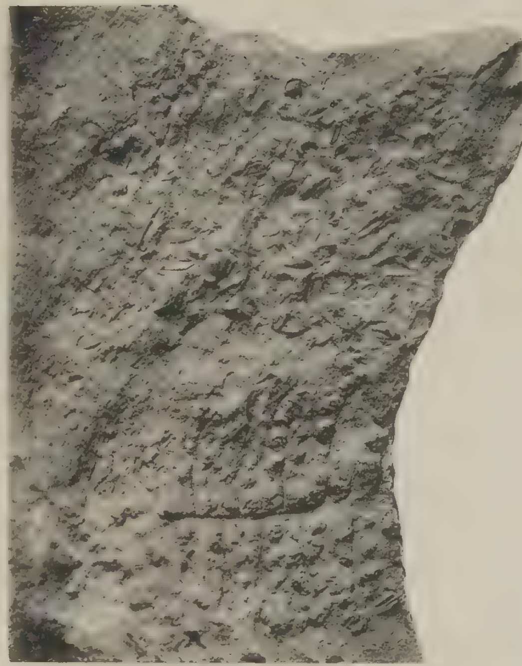

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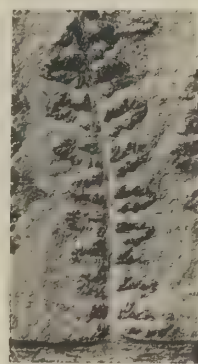

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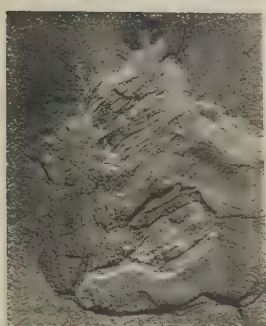

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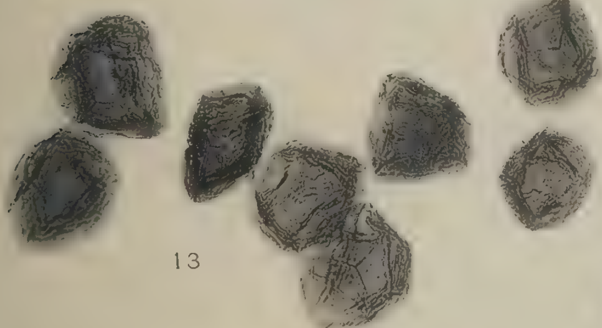

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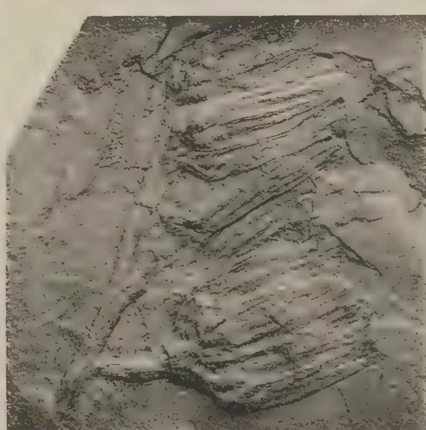

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PLATE CVIII.

Fig. 1. *Alcicornopteris convoluta* Kidston.

Portion of a frond, of which the naked petiole bifurcates at its apex and divides the frond into two primary sections.

Locality.—River Tweed, 100 yards below Norham Castle, Northumberland.

Horizon.—Cementstone Group. Calciferous Sandstone Series.

Natural size. Collection of Geological Survey, Edinburgh.

Fig. 2 (=2*b* on Plate). *Alcicornopteris convoluta* Kidston.

Fragment of a frond, showing the dichotomous division of the petiole.

Locality.—Shore, ½ mile east of Cove Harbour, 1½ miles north-east of Cockburnspath, Berwickshire.

Horizon.—Cementstone Group. Calciferous Sandstone Series.

Natural size. Collection of Geological Survey, Edinburgh, No. G. 2.

Fig. 3. *Alcicornopteris convoluta* Kidston.

Fragment of a frond.

Locality.—Right Bank of Whiteadder Water, ¾ mile below Allanton, Berwickshire.

Horizon.—Cementstone Group. Calciferous Sandstone Series.

Natural size. Kidston Collection, No. 2749.

Fig. 4 (=4*b* on Plate). *Alcicornopteris convcluta* Kidston.

Locality.—River Tweed, 100 yards below Norham Castle, Northumberland.

Horizon.—Cementstone Group. Calciferous Sandstone Series.

Natural size. Kidston Collection, No. 922.

Fig. 5. *Alcicornopteris convoluta* Kidston.

Portion of a frond.

Locality.—Long Craigs Bay, east of Dunbar, Haddingtonshire.

Horizon.—Cementstone Group. Calciferous Sandstone Series.

Natural size. Collection of Geological Survey, Edinburgh. No. B. 4585G.

Fig. 6. *Alcicornopteris convoluta* Kidston.

Fragment of a frond.

Locality.—Horncliffe Dean, near Mill, south of Horncliffe Village, Northumberland.

Horizon.—Cementstone Group. Calciferous Sandstone Series.

Natural size. Collection of Geological Survey, Edinburgh.

Fig. 7. *Alcicornopteris Zeilleri* Vaffier.

Fragment of a frond.

Locality.—Shore, about ¾ mile N.N.E. of Kinghorn, almost immediately below the Combination Poorhouse, Fife.

Horizon.—A short distance below the Hurlet Limestone. Oil-Shale Group. Calciferous Sandstone Series.

Natural size. Kidston Collection, No. 3076.

Fig. 7*a*. *Alcicornopteris Zeilleri* Vaffier.

Same specimen enlarged two times.

Fig. 8. *Alcicornopteris Zeilleri* Vaffier.

Fragment of a frond.

Same locality and horizon as last specimen.

Natural size. Kidston Collection, No. 3077.

Fig. 9. *Alcicornopteris sp.*

Fragments of synangia.

Locality.—Escarpment on south side of Loch Humphrey Burn, where stream from waterfall enters at about ½ mile below the Loch, Dumbartonshire.

Horizon.—Oil-Shale Group. Calciferous Sandstone Series.

Natural size. Collection of Geological Survey, Edinburgh. No. M. 411D.

Fig. 9*a*. *Alcicornopteris sp.*

Two of the synangia from last specimen, enlarged two times to show the form of the sporangia.


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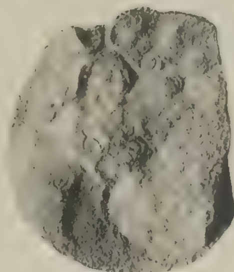
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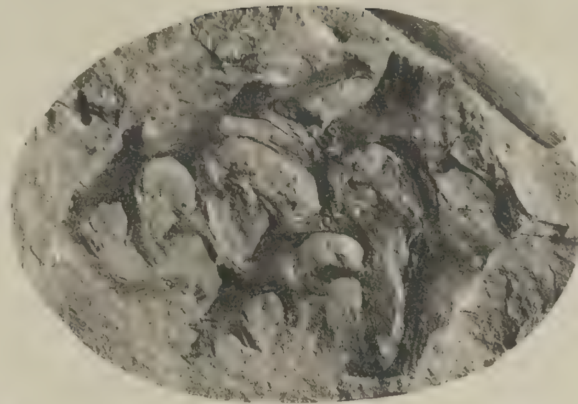
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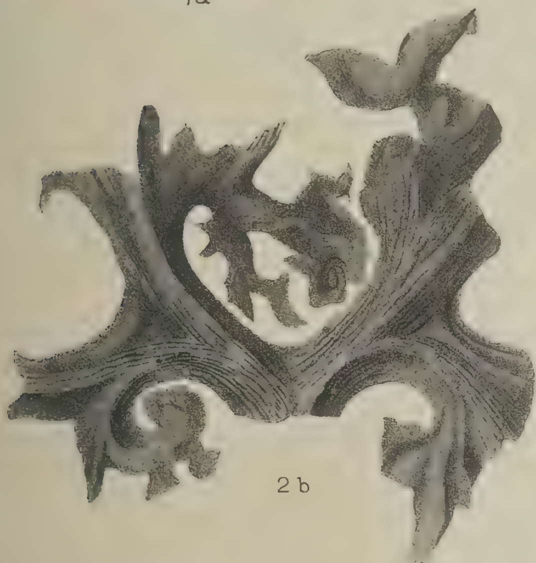
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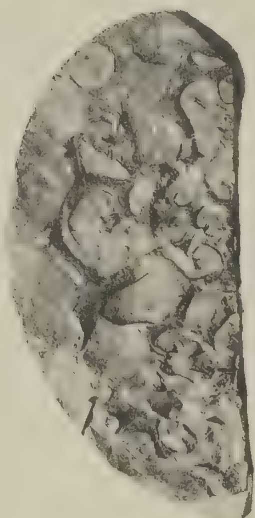
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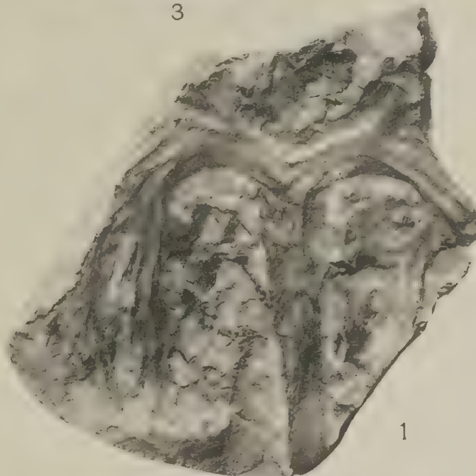
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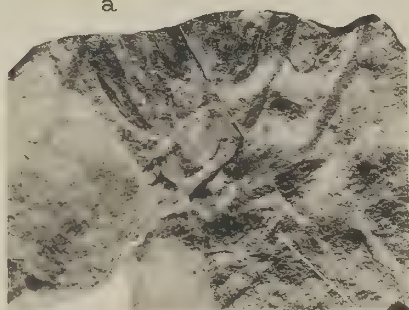
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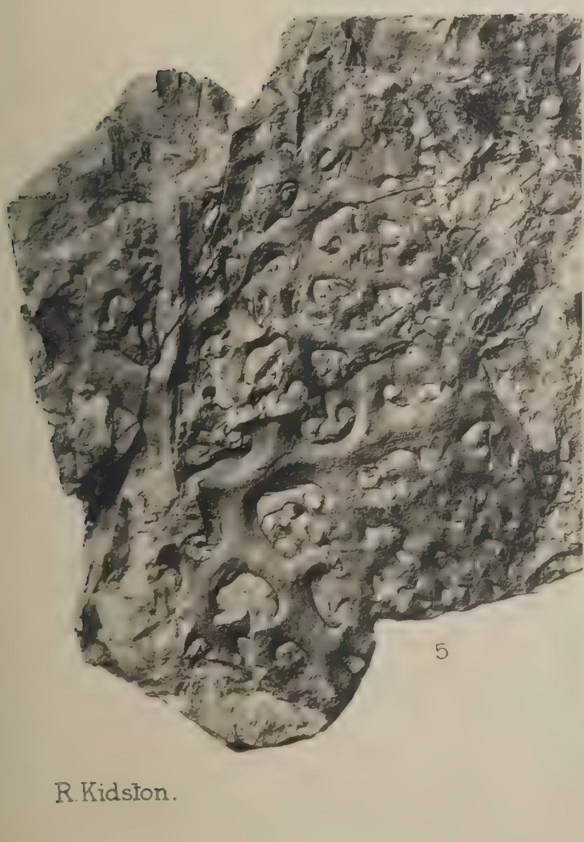
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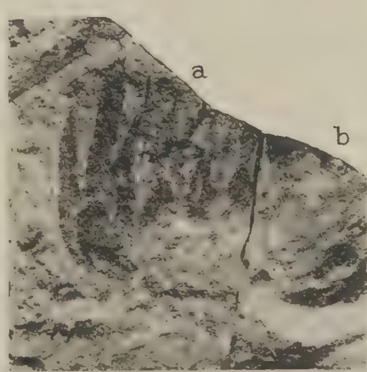
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PLATE CIX.

Fig. 1. *Dicksonites Pluckeneti* Schlotheim sp.
Fragment of a pinna.
Locality.—Braysdown Colliery, near Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 234.

Fig. 1*a*. *Dicksonites Pluckeneti* Schlotheim sp.
Base of an ultimate pinna from the last specimen, enlarged about three and a half times to show the form of the pinnules.

Fig. 2. *Dicksonites Pluckeneti* Schlotheim sp.
Portion of a pinna showing hemispherical protuberances on the upper surface of the pinnules.
Locality.—Welton Colliery, near Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Collected by the late E. Wilson. Kidston Collection, No. 236.

Fig. 2*a*. *Dicksonites Pluckeneti* Schlotheim sp.
The last specimen, enlarged two times to show more distinctly the arrangement of the protuberances.

Figs. 2*b*–2*d*. *Dicksonites Pluckeneti* Schlotheim sp.
Pinnules more highly enlarged.
From same specimen.

Fig. 3. *Dicksonites Pluckeneti* Schlotheim sp.
Portion of a pinna.
Locality.—Ludlow's Pit, Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 235.

Fig. 3*a*. *Dicksonites Pluckeneti* Schlotheim sp.
Pinnule from last specimen enlarged three and a half times to show the nervation.

Fig. 4. *Dicksonites Pluckeneti* Schlotheim sp.
Showing some of the sporangia which form the synangium at *a*.
Locality.—Cros, St Étienne, France.
From specimen received from M. F. Cyrille Grand'Eury.
Kidston Collection, No. 3873.

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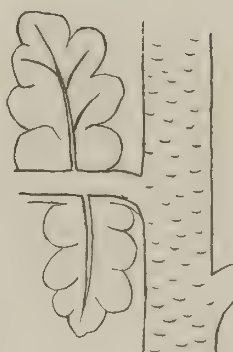
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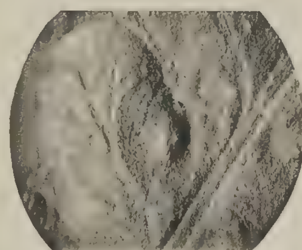
2a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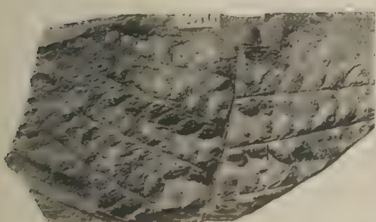
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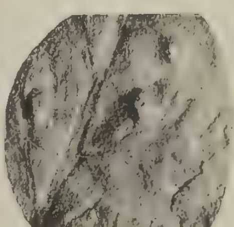
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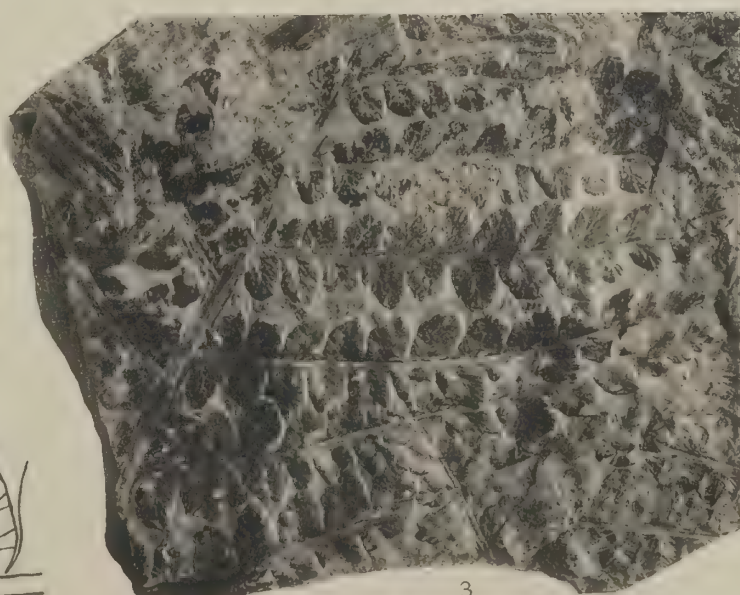
3


2d


3a

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PLATE CX.

Fig. 1. *Dactylotheca plumosa* Artis sp.

Portion of a pinna.

Locality.—East Newton, Fifeshire.

Horizon.—Lower Coxtool Coal. Lanarkian Series.

Natural size. Collected by the late J. W. Kirkby. Kidston Collection, No. 2113.

Fig. 2. *Dactylotheca plumosa* Artis sp.

Portion of a pinna.

Locality.—Hallhill Burn (tributary of River Nethan), fully 1 mile south-west of bridge across River Clyde at Crossford, Lanarkshire.

Horizon.—?. Lanarkian Series.

Natural size. Collection of Geological Survey, Edinburgh. No. T. 4430e.

Figs. 2*a*, 2*b*. *Dactylotheca plumosa* Artis sp.

Pinnules from last specimen, enlarged seven and a half times to show form and nervation.

Fig. 3. *Macrosphenopteris Lindsæoides* Kidston.

Portion of a frond or pinnule.

Locality.—Radstock, Somerset.

Horizon.—Radstock Group. Radstockian Series.

Natural size. Kidston Collection, No. 560.

Fig. 3*a*. *Macrosphenopteris Lindsæoides* Kidston.

Portion of same specimen, enlarged two times to show thickened margin.

Figs. 4–7. *Aneimites Acadica* Dawson.

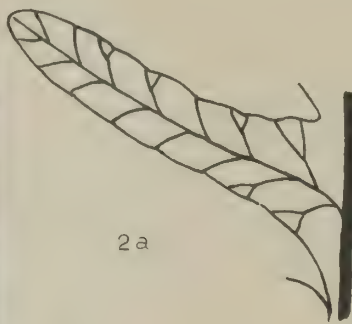
Fragments of pinnæ.

Locality.—Left bank of Crooked Burn, about 50 yards below Newton Farm, near Foulden, Berwickshire.

Horizon.—Cementstone Group. Calciferous Sandstone Series.

Natural size. Fig. 4 collected by the late T. Ovens. Kidston Collection, fig. 4, No. 4776; fig. 5, No. 4779; fig. 6, No. 4782; fig. 7, No. 4778.

1



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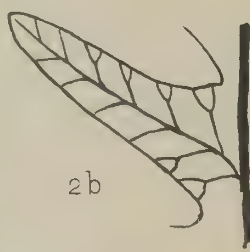

2b

2

7

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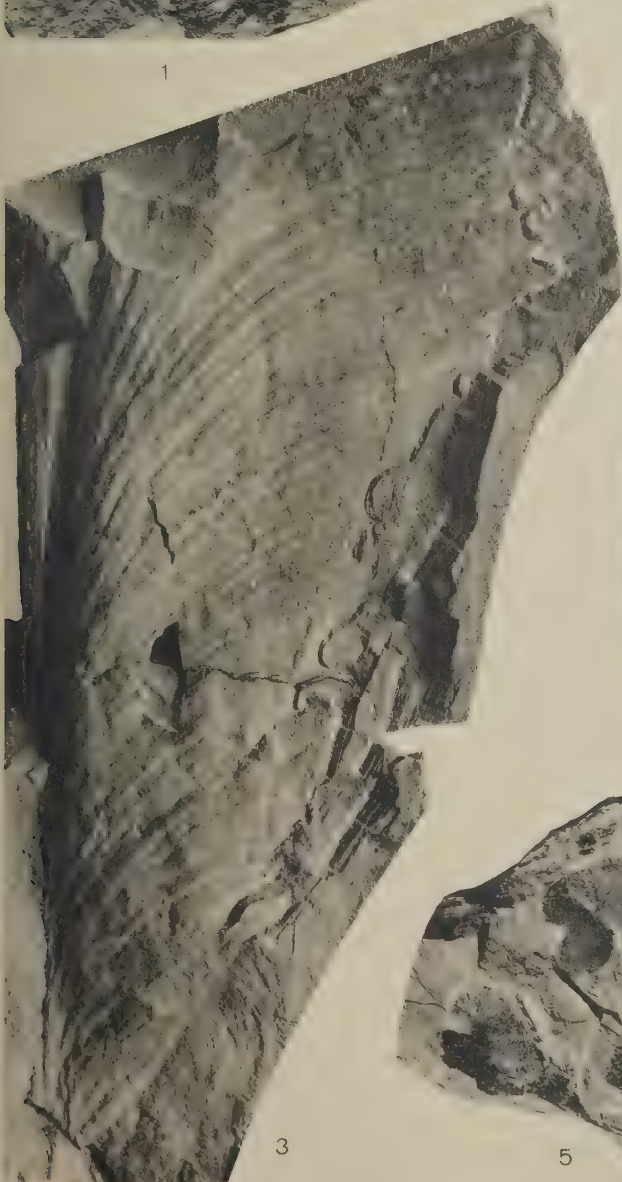
3a



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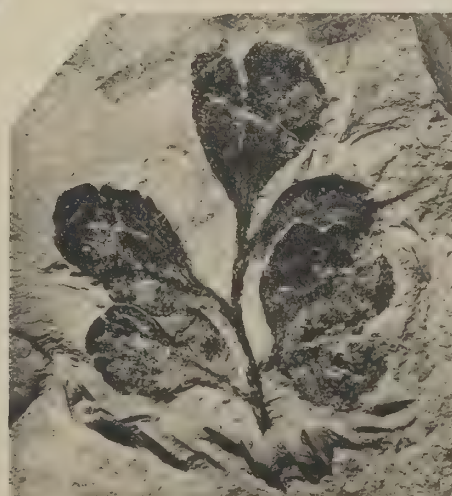

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PLATE CXI.

Fig. 1. *Eremopteris artemisiæfolia* Sternberg sp.
Portion of a frond.
Locality.—Fawdon, 3 miles north-west of Newcastle-upon-Tyne, Northumberland.
Horizon.—High Main Seam. Westphalian Series.
Natural size. Specimen in the Collection of the Hancock Museum, Newcastle-upon-Tyne.

Fig. 2. *Eremopteris artemisiæfolia* Sternberg sp.
Specimen showing a dichotomy of the rachis.
Locality.—Fawdon, 3 miles north-west of Newcastle-upon-Tyne.
Horizon.— ? High Main Seam. Westphalian Series.
Natural size. Specimen in the Hancock Museum, Newcastle-upon-Tyne.

Fig. 3. *Eremopteris artemisiæfolia* Sternberg sp.
Portion of a frond.
Locality.—Leven Colliery, Leven, Fifeshire.
Horizon.—Chemiss Coal. Lanarkian Series.
Natural size. Collected by the late J. W. Kirkby. Kidston Collection, No. 848.

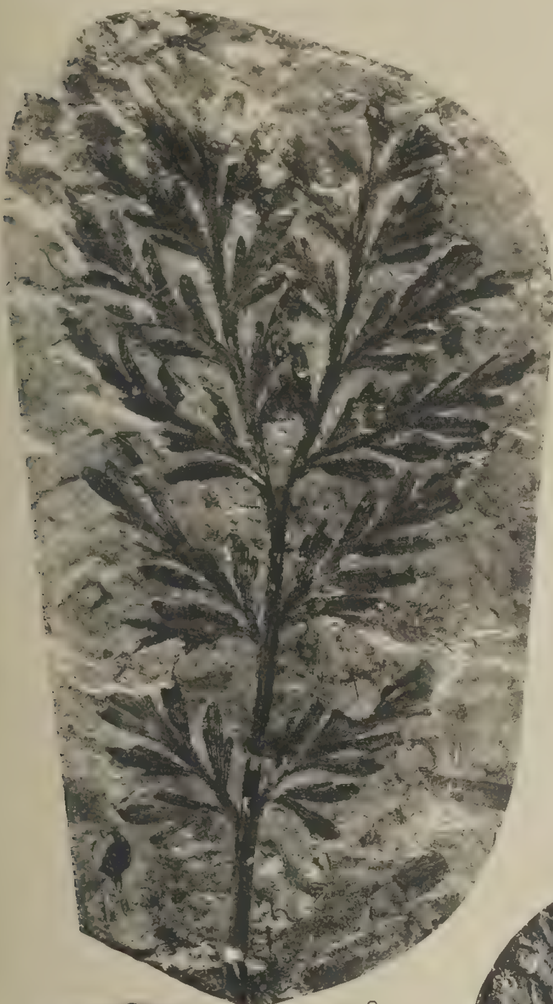
Fig. 4. *Eremopteris artemisiæfolia* Sternberg sp.
Pinnule enlarged about three and a half times to show the nervation.
Locality.—River South Esk, in Dalkeith Park, left bank, $\frac{1}{6}$ mile south-west of Smeaton Bridge, Midlothian.
Horizon.— ?. Lanarkian Series. Kidston Collection, No. 3315.

Fig. 5. *Eremopteris zamioides* P. Bertrand sp.
Terminal portion of a frond or pinna.
Locality.—Cadeby Colliery, Conisborough, Yorkshire.
Horizon.—Shale over Ackworth Rock. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1696.

Fig. 5*a*. *Eremopteris zamioides* P. Bertrand sp.
Pinnæ of last specimen enlarged two times to show form of pinnules.

Fig. 6. *Eremopteris zamioides* P. Bertrand sp.
Lower portion of a frond or pinna.
Same locality and horizon as last specimen.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1697.

Plate CXI.



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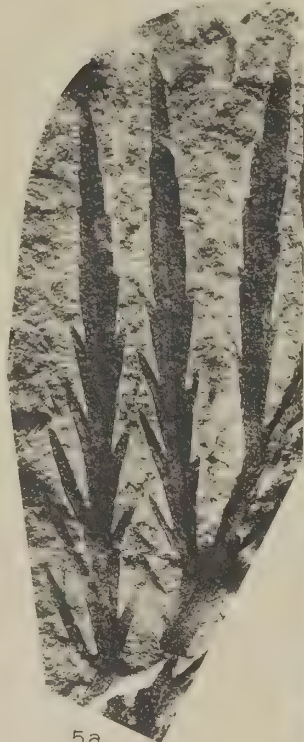
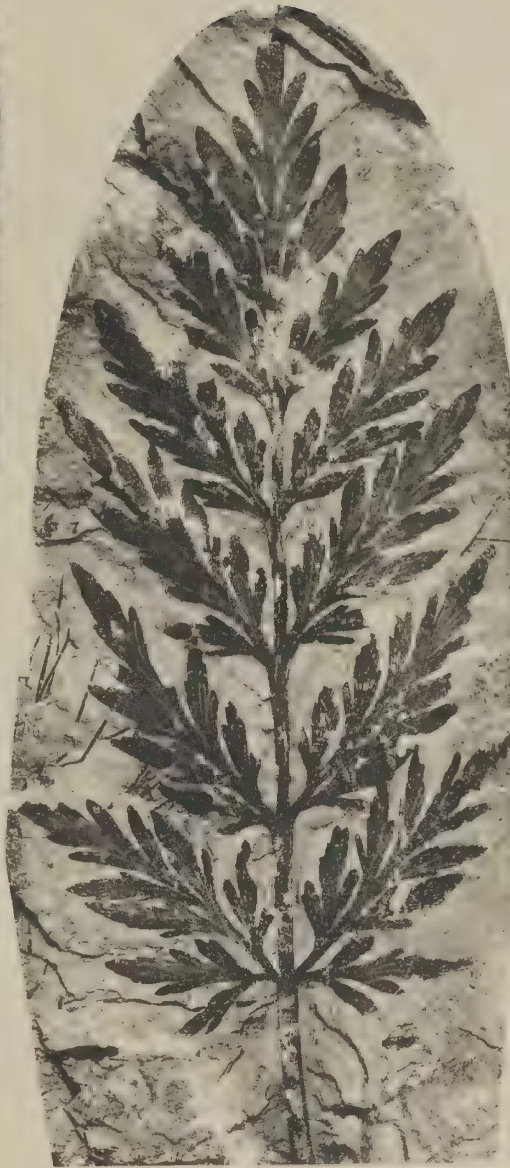


5a



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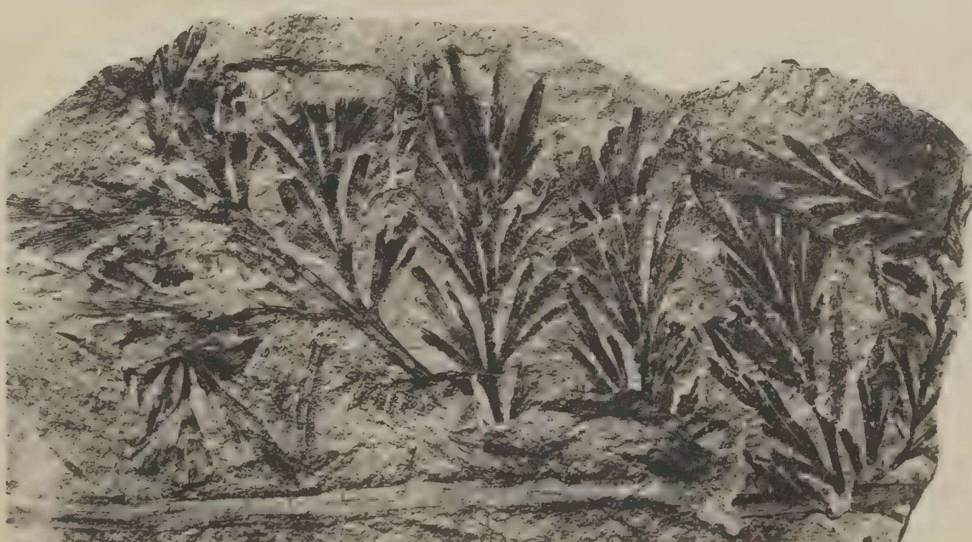

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PLATE CXII.

Fig. 1. *Telangium digitatum* Kidston n. sp.
Portions of two synangia.
Locality.—New Pit on road side, ½ mile east of Ballieston, Lanarkshire.
Horizon.—Shale above Ell Coal. Lanarkian Series.
Natural size. Collection of Geological Survey, Edinburgh, No. M. 2404A.

Fig. 1*a*. *Telangium digitatum* Kidston n. sp.
The same specimen, enlarged two times to show the form of the microsporangia.

Fig. 2. *Dactylotheca plumosa* Artis sp.
Portion of a frond.
Locality.—South Kirby Colliery, near Pontefract, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 2116.

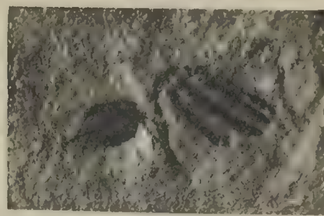
Fig. 2*a*. *Dactylotheca plumosa* Artis sp.
Part of a penultimate pinna from same specimen, enlarged two times to show form of pinnules and nervation.

Fig. 3. *Senftenbergia ophiodermatica* Göppert sp.
Fertile pinnules, enlarged twelve times to show the sporangia.
From specimen seen on Pl. XCVI, fig. 1.

Fig. 3*a*. *Senftenbergia ophiodermatica* Göppert sp.
Two sporangia *a*, *a* from same specimen, enlarged about twenty times to show more distinctly the apical annulus *b*, *b*.

Plate CXII.

2a



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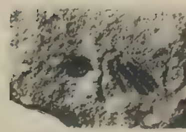

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3a

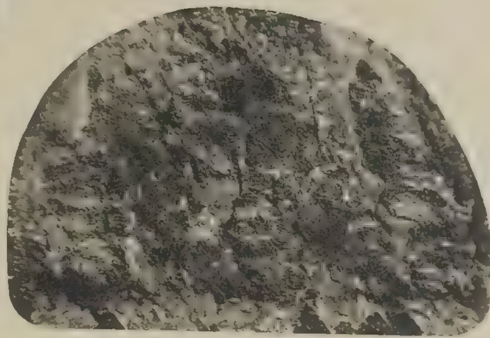

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PLATE CXIII.

Fig. 1. *Eremopteris artemisiæfolia* Sternberg sp.
The terminations of the two arms of a dichotomized pinna.
Locality.—Durie Colliery, Leven, Fifeshire.
Horizon.—Roof of Chemiss Coal. Lanarkian Series.
Natural size. Collected by the late J. W. Kirkby. Kidston Collection, No. 2016.

Fig. 2. *Eremopteris artemisiæfolia* Sternberg sp. forma *crithmifolia* L. and H. pro sp.
Same locality and horizon as last specimen.
Natural size. Collected by the late J. W. Kirkby. Kidston Collection, No. 2017.

Fig. 3. *Eremopteris artemisiæfolia* Sternberg sp.
Terminal portion of a dichotomous pinna.
Locality.—River South Esk, Dalkeith Park, left bank, $\frac{1}{8}$ mile south-west of Smeaton Bridge, Midlothian.
Horizon.—?. Lanarkian Series.
Natural size. Kidston Collection, No. 3315.

Fig. 3*a*. *Eremopteris artemisiæfolia* Sternberg sp.
Pinnules from near the apex of one of the arms of the same specimen, enlarged five and a half times to show the arrangement of the veins.

Fig. 4. *Zeilleria Moravica* Ettingshausen sp.
Portion of a frond.
Locality.—New Braidbar Quarry, Giffnock, Renfrewshire.
Horizon.—Immediately underneath the Orchard Limestone. Upper Limestone Group. Carboniferous Limestone Series.
Natural size. Kidston Collection, No. 2420.

Fig. 5. *Dactylotheca parallela* Kidston n. sp.
Part of a fertile frond.
Locality.—Lochwood Colliery, Easterhouse, Lanarkshire.
Horizon.—Kiltongue Coal. Westphalian Series.
Natural size. Kidston Collection, No. 2672.

Fig. 6. *Dactylotheca parallela* Kidston n. sp.
Portions of three ultimate pinnæ, enlarged two times to show the form of the pinnules.
From the same specimen.

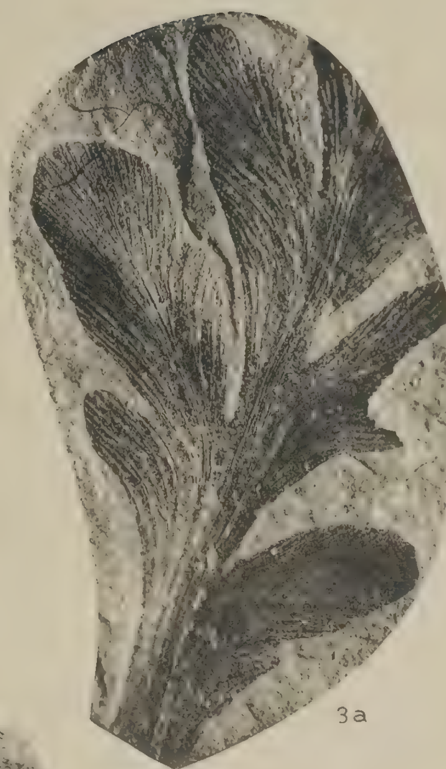
Fig. 7. *Dactylotheca parallela* Kidston n. sp.
Part of an ultimate pinna, enlarged about ten times to show the arrangement of the sporangia on the pinnules.
From the same specimen.

Fig. 8. *Dactylotheca parallela* Kidston n. sp.
Sporangia enlarged about twenty-five times to show the form and structure of the sporangial wall.
From the same specimen.

Plate CXIII.

1

2



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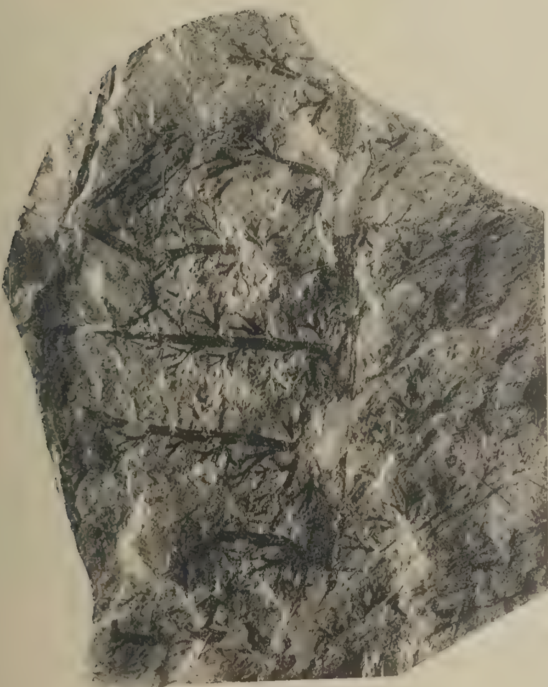

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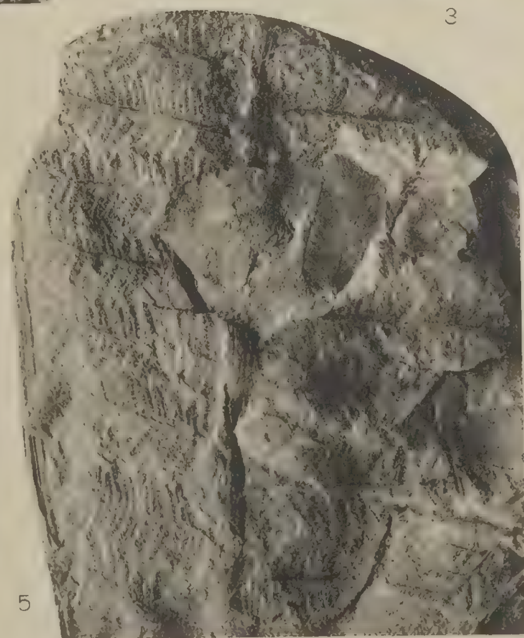

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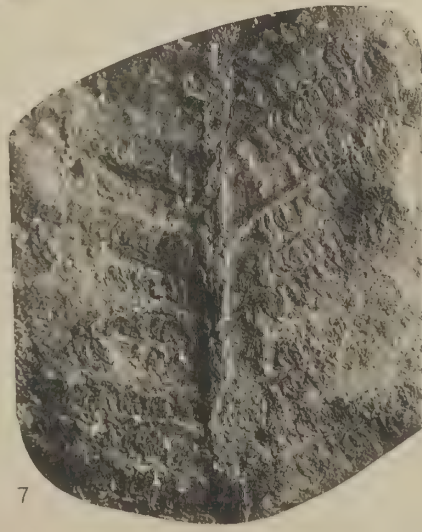

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PLATE CXIV.

Fig. 1. *Asterotheca arborescens* Schlotheim sp.
Portion of a primary pinna.
Locality.—Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 452.

Fig. 2. *Asterotheca cyathea* Schlotheim sp.
Terminal portion of a primary pinna.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstockian Group. Radstock Series.
Natural size. Kidston Collection, No. 460.

Fig. 2*a*. *Asterotheca cyathea* Schlotheim sp.
Upper part of same specimen, enlarged three times to show form of pinnules.

Fig. 2*b*. *Asterotheca cyathea* Schlotheim sp.
Pinnule from same specimen, enlarged seven times to show nervation.

Fig. 3. *Asterotheca cyathea* Schlotheim sp.
Under surface of a few pinnules, enlarged three times to show villose surface of pinnules.
Locality.—Upper Conygre Pit, Timsbury, 2½ miles N.N.W. of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Kidston Collection, No. 461.

Fig. 4. *Asterotheca crenulata* Brongniart sp.
Fragment of a primary pinna.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 473.

Fig. 4*a*. *Asterotheca crenulata* Brongniart sp.
Part of an ultimate pinna from same specimen, enlarged two and a half times to show the form of pinnules.

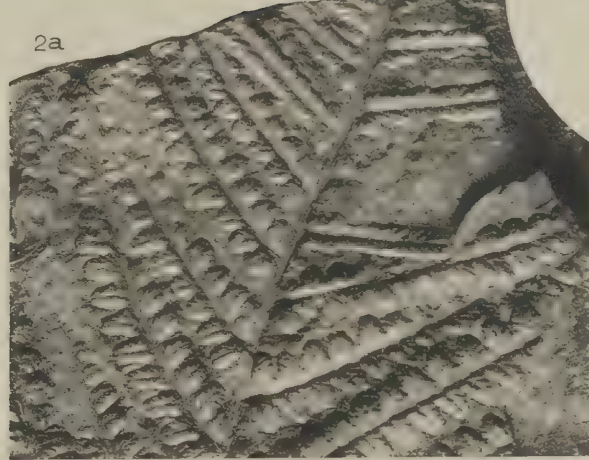
Fig. 4*b*. *Asterotheca crenulata* Brongniart sp.
Pinnule from same specimen, enlarged seven times to show nervation.

Palaeontology. Vol. II. 1924.

Plate CXIV.

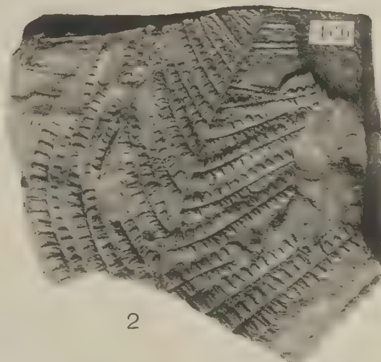
1

2b



2a

3



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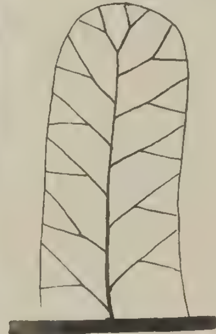

4b

4a

4

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PLATE CXV.

Fig. 1. *Asterotheca cyathea* Schlotheim sp.
Upper portion of a primary pinna.
Locality.—Wellsway Pit, Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 3846.

Fig. 1*a*. *Asterotheca cyathea* Schlotheim sp.
Part of an ultimate pinna from same specimen, enlarged three times to show irregularity in size of pinnule.

Fig. 1*b*. *Asterotheca cyathea* Schlotheim sp.
Pinnule from same specimen, enlarged seven times to show nervation.

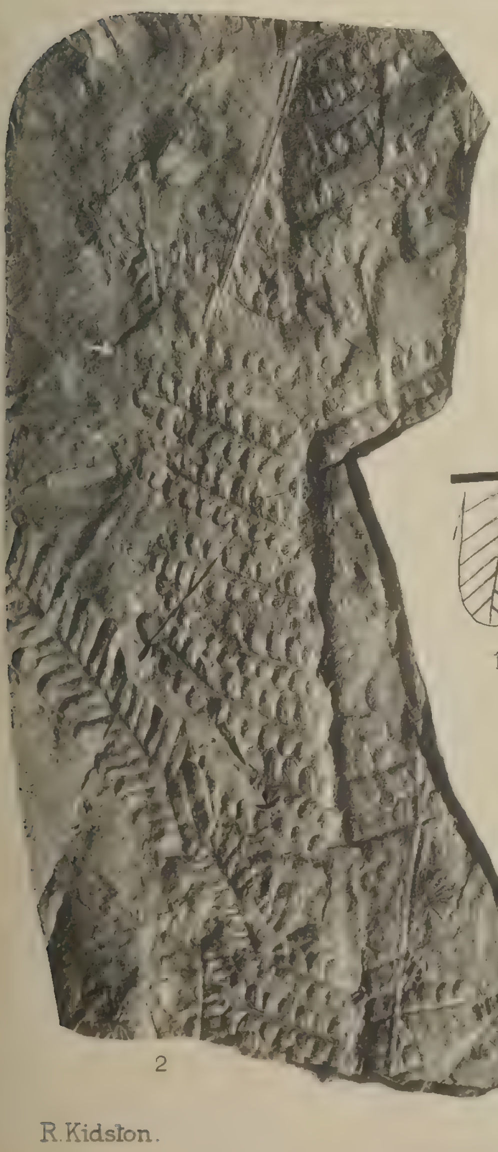
Fig. 2. *Eupecopteris Camertonensis* Kidston n. sp. (See page 486.)
Part of a (?) primary pinna.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 475.

Fig. 2*a*. *Eupecopteris Camertonensis* Kidston n. sp.
Portions of two ultimate pinnæ from same specimen, enlarged three times to show form of pinnules and their nervation.

Plate CXV.

1a

2a



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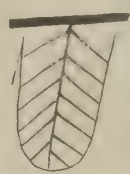

1b

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PLATE CXVI.

Fig. 1. *Asterotheca Candolleana* Brongniart sp.
Portion of a primary pinna.
Locality.—Braysdown Colliery, near Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 3858.

Fig. 2. *Asterotheca Candolleana* Brongniart sp.
Fragment of an ultimate pinna, enlarged two and a half times to show the nervation.
Same locality and horizon as last specimen.
Kidston Collection, No. 471.

Fig. 3. *Asterotheca cyathea* Schlotheim sp.
Fragment of a primary pinna.
Locality.—Ludlow's Pit, Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 454.

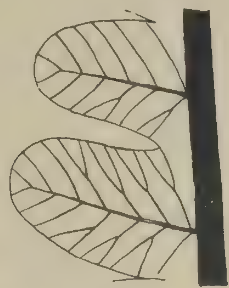
Fig. 3*a*. *Asterotheca cyathea* Schlotheim sp.
Upper portion of two ultimate pinnæ from last specimen, enlarged about two and a half times to show the tapering form of the pinnæ and the inequality in size of the pinnules.

Fig. 3*b*. *Asterotheca cyathea* Schlotheim sp.
Two pinnules from same specimen, enlarged seven times to show their form and nervation.

Fig. 4. *Asterotheca cyathea* Schlotheim sp.
Portion of a fertile ultimate pinna, enlarged three times to show the arrangement of the synangia.
Locality.—Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Kidston Collection, No. 456.

Plate CXVI.

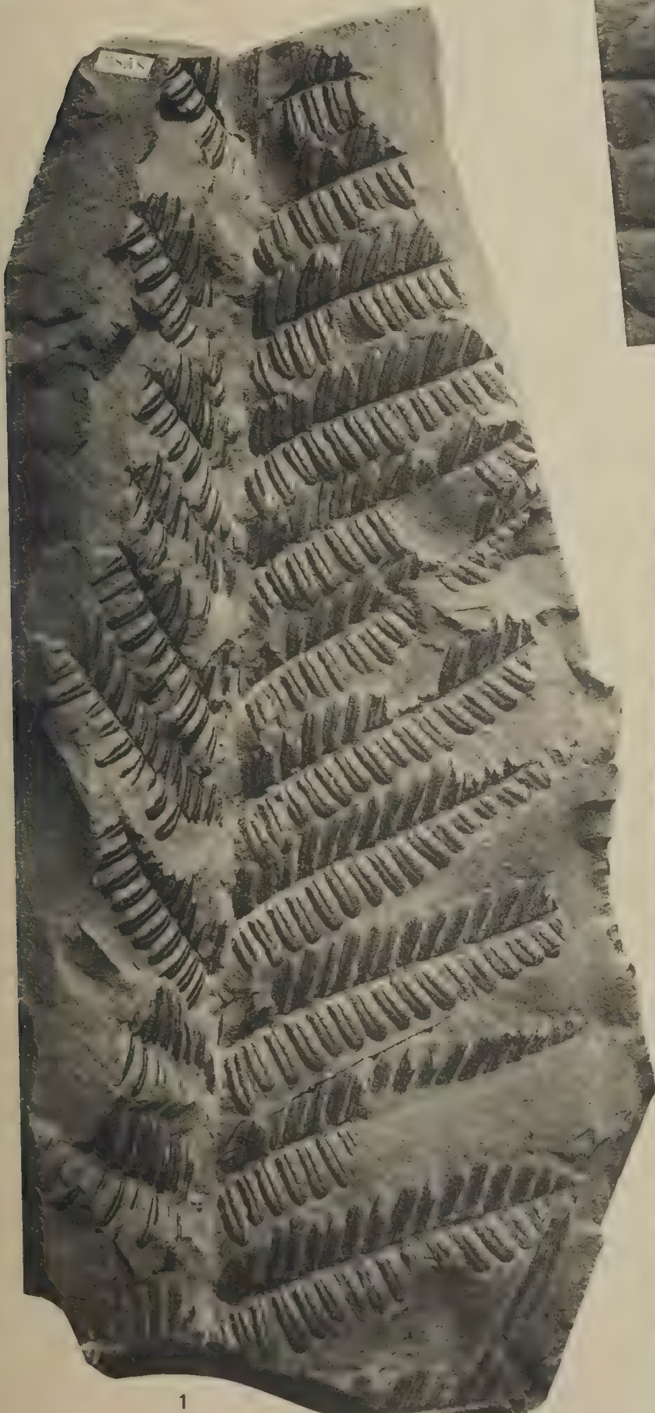
2



3b

4

3a



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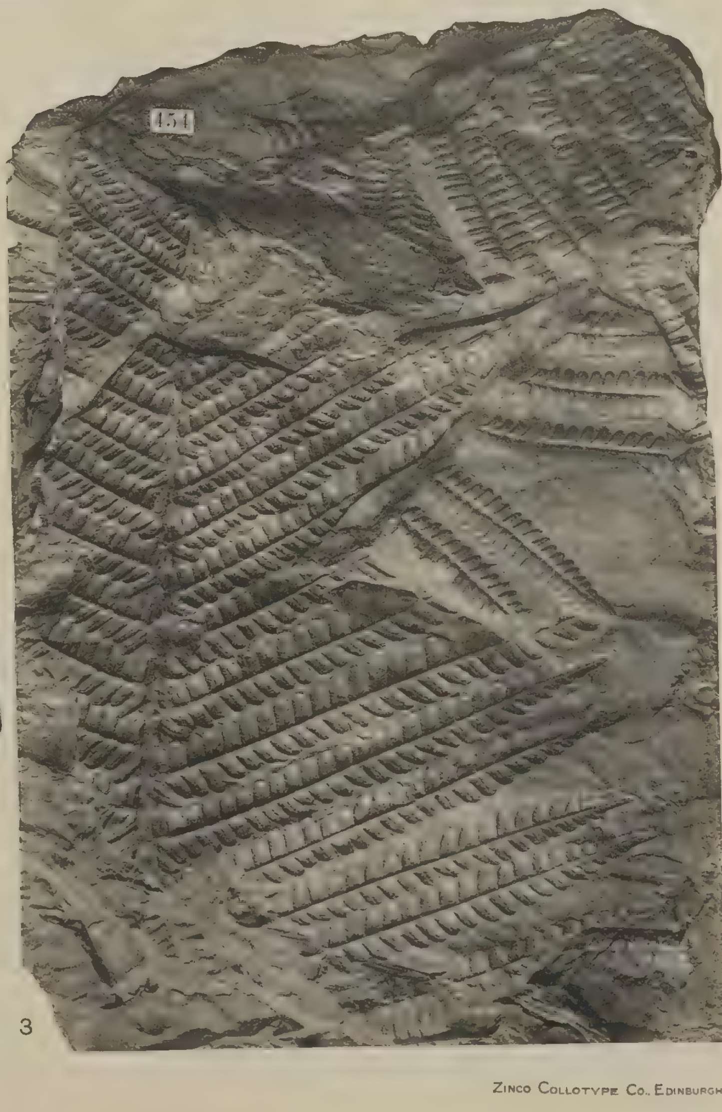

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PLATE CXVII.

Fig. 1. *Asterotheca hemitelioides* Brongniart sp.
Portion of a primary pinna.
Locality.—Kilmersdon Pit, near Radstock, Somerset.
Horizon.—Radstockian Series. Radstock Group.
Natural size. Kidston Collection, No. 3856.

Fig. 2. *Asterotheca hemitelioides* Brongniart sp.
Fragments of two fertile secondary pinnæ.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstockian Series. Radstock Group.
Natural size. Kidston Collection, No. 463.

Fig. 2*a*. *Asterotheca hemitelioides* Brongniart sp.
Portion of one of the pinnæ of same specimen, enlarged three times to show position of synangia.

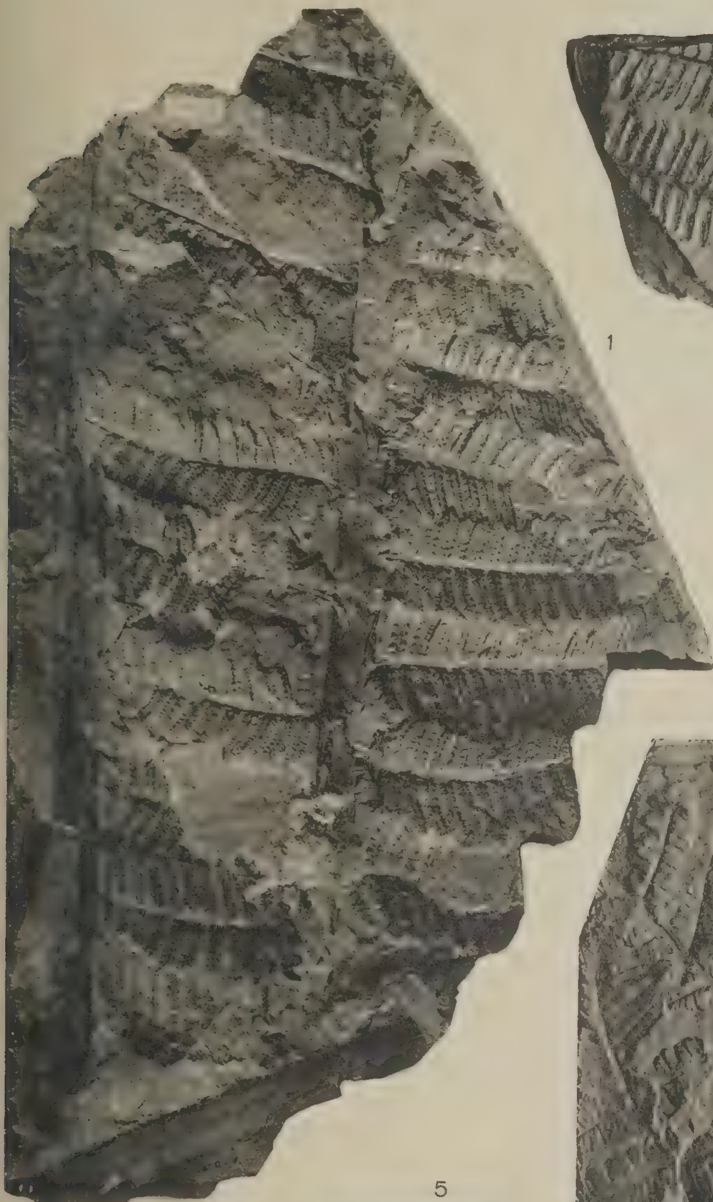
Fig. 3. *Asterotheca cyathea* Schlotheim sp.
Fragments of fertile and sterile pinnæ.
Locality.—Radstock, Somerset.
Horizon.—Radstockian Series. Radstock Group.
Natural size. Kidston Collection, No. 456.

Fig. 3*a*. *Asterotheca cyathea* Schlotheim sp.
Part of a sterile pinna from same specimen, enlarged three times to show the nervation.

Fig. 4. *Asterotheca hemitelioides* Brongniart sp.
Fragment of a secondary pinna, enlarged two times to show the nervation.
Locality.—Railway Cutting, Florence Colliery, Longton, North Staffordshire.
Horizon.—Staffordian Series. Newcastle-under-Lyme Group.
Natural size. Collected by Mr F. Barker. Kidston Collection, No. 3335.

Fig. 5. *Asterotheca hemitelioides* Brongniart sp.
Part of another secondary pinna on back of same specimen.

Plate CXVII.



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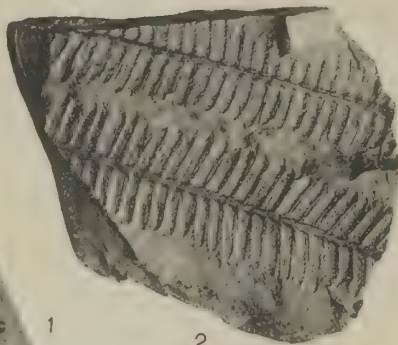

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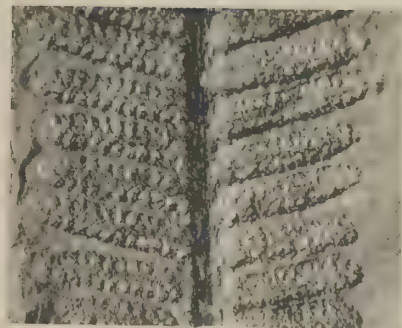

2a

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3a

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PLATE CXVIII.

Fig. 1. *Asterotheca oreopteridia* Schlotheim sp.

Parts of primary pinnæ.

Locality.—Braysdown Colliery, near Radstock, Somerset.

Horizon.—Radstockian Series. Radstock Group.

Natural size. Collected by Mr Steart. Kidston Collection, No. 508.

Fig. 1*a*. *Asterotheca oreopteridia* Schlotheim sp.

Pinnules from same specimen, enlarged three times to show nervation.

Fig. 2. *Asterotheca oreopteridia* Schlotheim sp.

Fragment of a primary pinna.

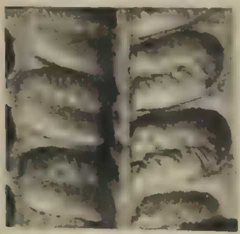
Locality.—Granville Pit, Old Hill Station, 1½ miles north-east of Halesowen, South Staffordshire.

Horizon.—Old Hill Marls. Staffordian Series. Etruria Marl Group.

Natural size. Collected by Rev. H. Kay. Kidston Collection, No. 5998.

Fig. 2*a*. *Asterotheca oreopteridia* Schlotheim sp.

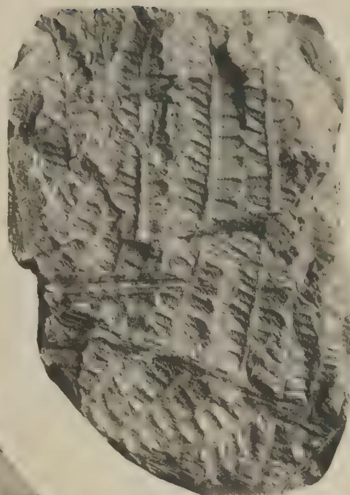
Secondary pinnæ of last specimen, enlarged two times to show form of pinnules and their nervation.



1a

2a

1



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R Kidston.

Zinco Collotype Co. Edinburgh

PLATE CXIX.

Fig. 1. *Asterotheca oreopteridia* Schlotheim sp.

Portions of two fertile primary pinnæ.

Locality.—Camerton, 2 miles north of Radstock, Somerset.

Horizon.—Radstockian Series. Radstock Group.

Natural size. Collected by Mr J. Moon. Kidston Collection, No. 506.

Fig. 2. *Asterotheca oreopteridia* Schlotheim sp.

Portion of fertile secondary pinna, enlarged two times to show villose surface of the fertile pinnules and the absence of the villosity on the sterile ones.

From same specimen.

Fig. 3. *Asterotheca oreopteridia* Schlotheim sp.

Two fertile pinnules, showing their villose upper surface. Enlarged five times.

From same specimen.

Fig. 4. *Asterotheca oreopteridia* Schlotheim sp.

Sterile pinnules from lower portion of specimen seen at fig. 1, enlarged two times to show the nervation.

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PLATE CXX.

Fig. 1. *Asterotheca Miltoni* Artis sp.

Fragment of a secondary pinna, enlarged three times to show nervation and form of the pinnules.

Locality.—South Kirkby Colliery, near Pontefract, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Collected by Mr W. Hemingway. Kidston Collection, No. 1719.

Fig. 2. *Asterotheca Miltoni* Artis sp.

Apical portions of three fertile secondary pinnæ.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Collected by Mr W. Hemingway. Kidston Collection, No. 2146.

Fig. 2*a*. *Asterotheca Miltoni* Artis sp.

Some pinnules from last specimen, enlarged six and a half times to show the synangia.

Fig. 2*b*. *Asterotheca Miltoni* Artis sp.

Synangium from same specimen, more highly enlarged to show the form of the sporangia.

Fig. 3. *Asterotheca Miltoni* Artis sp.

Fragment of a primary pinna.

Same locality and horizon as last specimen.

Enlarged three times to show the nervation.

Collected by Mr W. Hemingway. Kidston Collection, No. 1144.

Fig. 3*a*. *Asterotheca Miltoni* Artis sp.

Pinnule from last specimen, enlarged seven times to show the union of the pinnules at the base and the nervation.

Fig. 4. *Asterotheca Miltoni* Artis sp.

Portion of a fertile primary pinna, showing the arrangement of the synangia on the pinnules.

Locality and horizon same as specimen given at fig. 2.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 3972.

Fig. 5. *Asterotheca* cf. *Miltoni* Artis sp.

Synangium much enlarged.

Locality.—Jackfield Colliery, near Hanley, North Staffordshire.

Horizon.—About the horizon of the Bassey Mine. Staffordian Series. Blackband Group.

Kidston Collection, No. 2077.

Fig. 6. *Eupecopteris Bucklandi* Brongniart sp.

Portion of a primary pinna.

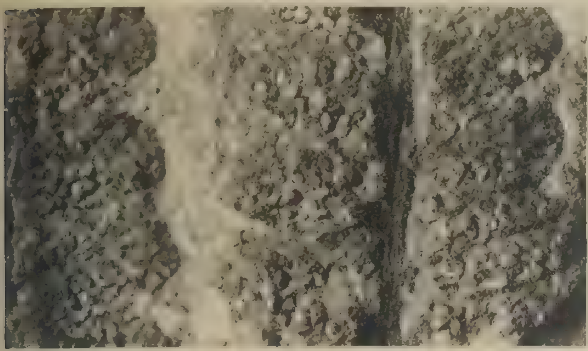
Locality.—Camerton, 2 miles north of Radstock, Somerset.

Horizon.—Radstockian Series. Radstock Group.

Natural size. Kidston Collection, No. 487.

Fig. 6*a*. *Eupecopteris Bucklandi* Brongniart sp.

Pinnules from last specimen enlarged three times to show their form and nervation.



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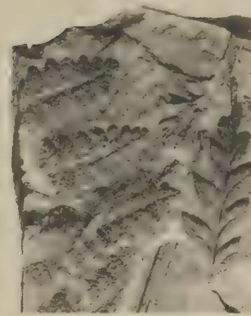

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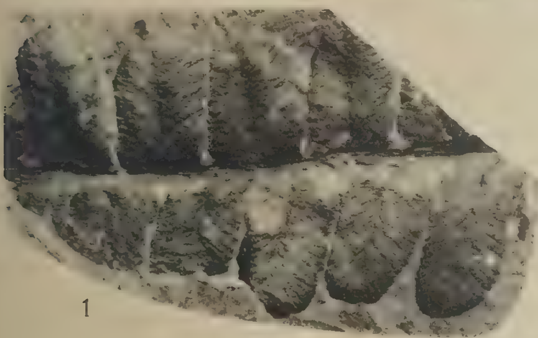
2b



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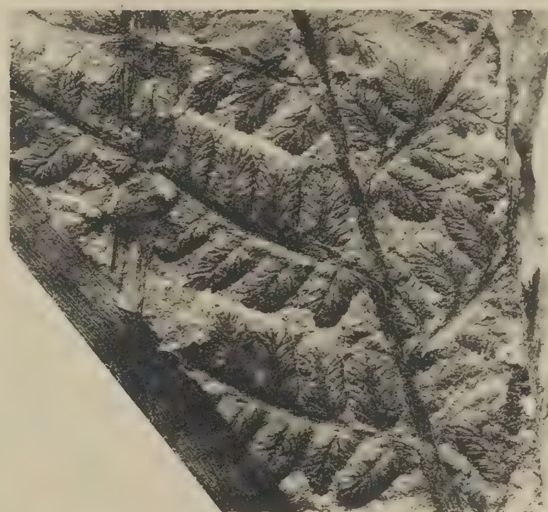
3a



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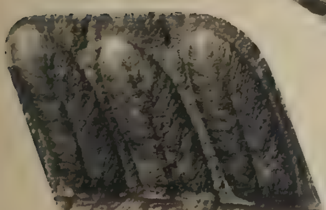

6a

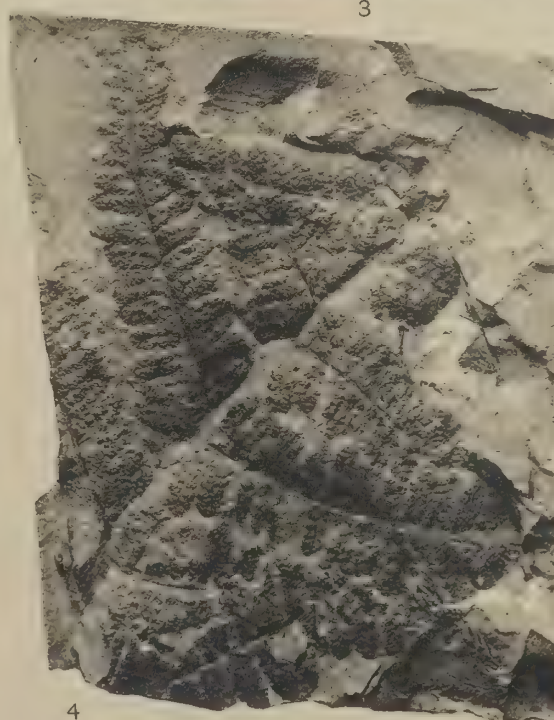

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PLATE CXXI.

Fig. 1. *Asterotheca Miltoni* Artis sp.

Two secondary pinnæ from near the apex of a primary pinna, showing the confluence of the pinnules.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Enlarged three times to show nervation and villose surface of the pinnules.

Collected by Mr W. HEMINGWAY. Kidston Collection, No. 1715.

Fig. 2. *Asterotheca Miltoni* Artis sp.

Portions of secondary pinnæ.

Locality.—Ludlow's Pit, Radstock, Somerset.

Horizon.—Radstockian Series. Radstock Group.

Natural size. Kidston Collection, No. 583.

Fig. 2*a*. *Asterotheca Miltoni* Artis sp.

Upper portion of a secondary pinna from same specimen, enlarged three times to show nervation.

Fig. 3. *Asterotheca Miltoni* Artis sp.

Portion of a primary pinna.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 1713.

Fig. 4. *Asterotheca Miltoni* Artis sp.

Upper portion of primary pinna, probably from the lower region of the frond.

Locality.—Wellsway Pit, Radstock, Somerset.

Horizon.—Radstockian Series. Radstock Group.

Natural size. Kidston Collection, No. 562.

Fig. 4*a*. *Asterotheca Miltoni* Artis sp.

Some secondary pinnæ from the same specimen, enlarged three times to show the union of the pinnules and their nervation.

Plate CXXI.

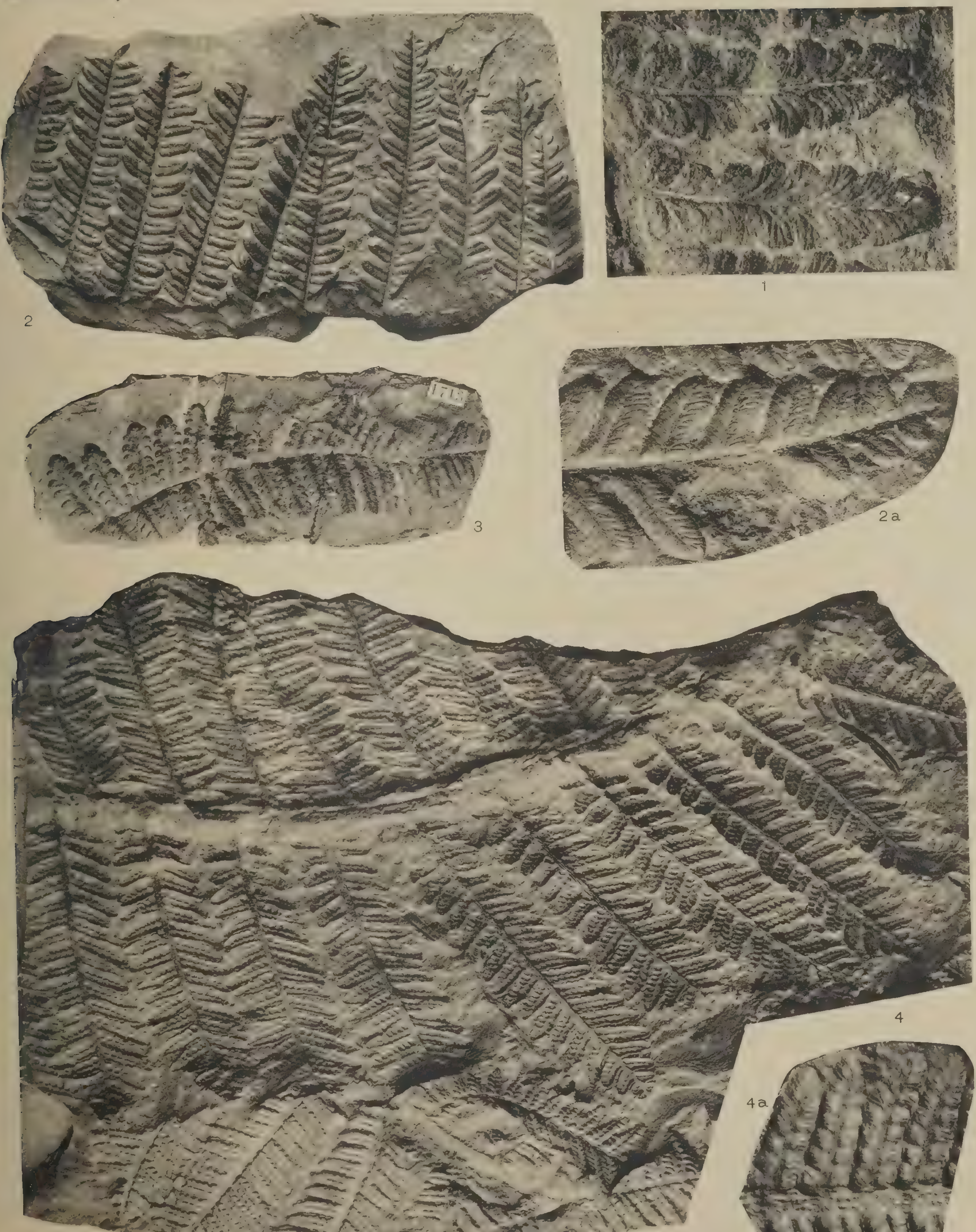

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PLATE CXXII.

Fig. 1. *Asterotheca Miltoni* Artis sp.

Fragments of quadripinnate primary pinnæ from the base of the frond.
Locality.—Ludlow's Pit, Radstock, Somerset.
Horizon.—Radstock Series. Radstockian Group.
Natural size. Kidston Collection, No. 581.

Fig. 1*a*. *Asterotheca Miltoni* Artis sp.

Some tertiary pinnæ from same specimen, enlarged three times.

1

1a

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MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

PALÆONTOLOGY.

VOL. II. PART 6.
PAGES 523–670; PLATES CXXIII–CLIII;
With TITLE-PAGE, &c. (PAGES i–xii) and INDEX (PAGES 671–681).

FOSSIL PLANTS
OF THE
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BY
ROBERT KIDSTON, LL.D., D.Sc., F.R.S. L. & E., F.G.S.

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INDEX TO SPECIES DESCRIBED IN PART 6.

LIST OF TEXT-FIGURES.

Asterotheca lepidorachis Brongniart sp.

Plate CXXVII, figs. 1, 1*a*, 1*b* ; 2, 2*a* ; text-fig. 61.

1834. *Pecopteris lepidorachis* Brongniart, " Hist. des végét. foss.," p. 313, pl. ciii, fig. 1.
1883. *Pecopteris lepidorachis* Renault, " Cours de botan. foss.," vol. iii, p. 111, pl. xviii, figs. 9, 10.
1888. *Pecopteris* (*Asterotheca*) *lepidorachis* Zeiller, " Flore foss. terr. houil. de Commentry," pt. 1, *Bull. Soc. Ind. Min.*, ser. 3, vol. ii, livr. 2, p. 123, pl. xiii, fig. 5 ; pl. xiv, figs. 1–3.
1893. *Pecopteris lepidorachis* Potonié, " Flora d. Rothl. von Thüringen," *Abhandl. k. preuss. geol. Landesanst.*, Heft 9, p. 72, pl. v, fig. 2.
1836. *Cyatheites lepidorachis* Göppert, " Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 322.
1877. *Pecopteris Candolleana* Grand'Eury (*non* Brongniart) (*pars*), " Flore Carb. du Dépt. de la Loire," *Mém. Acad. Sci. Paris*, xxiv, no. 1, p. 69, pl. viii, fig. 8.
1883. *Pecopteris Candolleana* Renault (*non* Brongniart) (*pars*), " Cours de botan. foss.," vol. iii, p. 109, pl. xvii, figs. 8, 8 *bis*.

Description.—Frond very large, tripinnate. Main rachis straight, 5 cm. in breadth, and bearing prominent, irregularly distributed apiculi from which the rarely preserved scales have fallen. Primary pinnæ touching laterally or overlapping, alternate, oblique to main rachis, attaining a length of 70 cm. and a breadth of 20 cm., lanceolate, slightly narrowed at base, then of almost equal width till near their summit, where they contract into a point with an obtuse apex ; rachis straight, apiculate. Secondary pinnæ spreading out at almost right angles to the primary rachis, or slightly oblique, attaining a length of 12 cm. and a breadth of 3 cm., lanceolate, of almost the same width till near their summit, where they terminate in an obtuse point ; rachis with a few scattered apiculi, stout, about 1·50 mm. in breadth at base, rounded on the back and furrowed on the upper surface.

Pinnules alternate, oblong, with parallel sides and bluntly rounded apices, attached by the whole width of their base, contiguous, free, sometimes decurrent and slightly united to each other, from two to three and a half times longer than broad according to their position on the frond. They vary in length from 3 mm. in the upper pinnæ to 15 mm. on the lower-placed pinnæ, and have a breadth of from 2 mm. to 5 mm.

At the summit of the primary pinnæ and of the frond the secondary pinnæ become pinnate, then pinnatifid, and finally assume the form of entire, elongated pinnules.

Nervation often indistinct, median vein straight, extending to the apex of the pinnule, lateral veinlets going off at an open angle, slightly arcuate, bifurcating into two arms near the base, of which the inferior arm remains single, but the superior arm sometimes again divides.

Fertile pinnæ and pinnules similar in form to the sterile ones. Pinnæ may be fertile throughout or the apical portion remain sterile. Sporangia ovoid, pointed

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at the summit, united to each other at the base and form rectangular synangia composed usually of four sporangia, contiguous and placed in two rows, one on each side of the midrib. The sporangia near the margin of the pinnule are usually longer than those next the median vein.

Remarks.—Asterotheca lepidorachis Brongniart sp., as judged by the size of the main rachis, must have had fronds of very large size, perhaps larger than those of any other species of *Asterotheca* or allied genera.

The specimen, of which part is given at fig. 1, Pl. CXXVII, is only a fragment of a frond and covers a slab 36 cm. by 34 cm. It shows part of the main rachis of the frond, 34 cm. in length, which passes obliquely across the slab. At the upper end this is about 7 mm. in breadth, and at the base about 12 mm. A part of the main rachis is seen at the bottom of the figure. It is densely apiculate, but this character is not well shown on the Plate. On one side of the rachis the remains of five primary pinnæ are seen ; and on the other, small portions of two other pinnæ. The specimen appears to have been part of the upper region of the frond, since the secondary pinnæ, measured from the lower end of the frond upwards, are distant from each other 10·5 cm., 8·5 cm., and 5 cm. The rachis of the lowest-placed primary pinna is about 9 mm. in breadth. The secondary pinnæ depart from the main rachis at an angle of about 45°. All are imperfect; and though the most complete is 26 cm. in length, neither it nor any of the other pinnæ shows any diminution in width up to the point where they are broken over, and therefore it is quite impossible to form any estimate of what their complete length might have been.

The longer secondary pinnæ are lanceolate, of almost equal width for two-thirds of their length, when they taper gradually and terminate in a blunt lobe. At a distance of about 12 cm. above the base of the primary pinnæ, the secondary pinnæ gradually decrease in length as traced downwards, though not in breadth, and at the base are scarcely 4 cm. in length.

The pinnules stand almost at right angles to the rachis, or slightly oblique to it. They are closely placed to each other, free or slightly decurrent, and may be united at the base, but only to a very slight extent. These conditions are seen in the enlargements given at figs. 1*a* and 1*b*. As a rule all the pinnules are of about the same width, but vary considerably in their length.

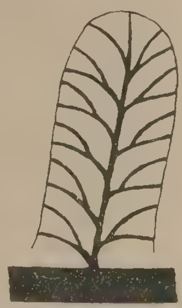
Some years ago I sent a photograph of the specimen described above, which forms the subject of fig. 1, Pl. CXXVII, to the late Professor ZEILLER, as it seemed to hold an intermediate position between *Asterotheca lepidorachis* Brongniart sp. and his *Pecopteris* (*Asterotheca* ?) *paleacea*.* He, however, had no doubt as to its being *Pecopteris lepidorachis*, and pointed out that in his *Pecopteris paleacea* the pinnules were shorter and the lateral veinlets did not dichotomize to the same extent as in *Asterotheca lepidorachis*, but suggested that perhaps the former should be united with the latter.

Between the size of the pinnules on some of the pinnæ of our specimen of *Astero-*

* "Flore foss. terr. houil. de Commentry," pt. 1, p. 116, pl. xi, fig. 5 ; pl. xii, figs. 1, 2.

theca lepidorachis and those on the figured specimens of *Pecopteris paleacea* there is very little difference, and the length of the pinnules of *Asterotheca lepidorachis* is known to vary considerably on different regions of the frond.

On the specimen, of which fig. 1 shows a part, the lateral veinlets are invariably only once divided, as seen at figs. 1*a* and 1*b*, which are enlarged three times, and at text-fig. 61, where a pinnule is enlarged seven times to show the nervation more distinctly. In the small fragment of a secondary pinna, shown at fig. 2 and enlarged two times at fig. 2*a*, which is provisionally referred to *Asterotheca lepidorachis*, the lateral veinlets in the upper pinnules are almost all only once divided, but in the lower and slightly larger pinnules the upper arm of the fork frequently again divides, while the lower arm remains simple. This, however, seems to be characteristic of the larger pinnules of the species.*



TEXT-FIG. 61.—*Asterotheca lepidorachis* Brongniart sp. Pinnule enlarged seven times to show the nervation.

Asterotheca lepidorachis differs from *Asterotheca Candolliana* Brongniart sp., with which some have proposed to unite it, in its closely placed pinnules, which are never contracted at the base, and its apiculate rachises of various degrees. In *Asterotheca Candolliana*, on the other hand, the pinnules are more or less distant, contracted at the base on the anterior side and frequently also on the posterior side, and the rachis is smooth or only marked with fine longitudinal striations.

Distribution.—Asterotheca lepidorachis is a very rare British species, and with the exception of the example of which a portion is given on Pl. CXXVII, fig. 1, which comes from the Radstock Group, the few other specimens which are provisionally referred to it are all very fragmentary and scarcely in a condition to admit of a satisfactory determination. One of these is given at fig. 2, Pl. CXXVII.

RADSTOCKIAN SERIES.

SOMERSET AND BRISTOL COALFIELD.

RADSTOCK GROUP.

Horizon: ?. *Locality:* Camerton, 2 miles north of Radstock, Somerset (G. WEST).

Cf. *Asterotheca lepidorachis* Brongniart sp.

STAFFORDIAN SERIES.

SHREWSBURY COALFIELD.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: Half-yard Coal. *Locality:* Hanwood Pit, midway between Hanwood and Cruckmeole, 4 miles south-west of Shrewsbury.

* *Cf.* BRONGNIART, "Hist. des végét. foss.," pl. ciii, fig. 1A.

Horizon : ?. *Locality :* Old Shaft south of Broxton Wood, 400 yards E.S.E. of Westbury Village (Collection Geological Survey, London).

SOUTH WALES COALFIELD.

NEWCASTLE-UNDER-LYME GROUP.

Horizon : Darrenddu Seam. *Locality :* Mynachdy Colliery, Old Ynysybwl, near Pontypridd, Glamorganshire (D. DAVIES).

Asterotheca Daubreei Zeiller sp.

Plate CXXIII, figs. 1–3 ; Plate CXXIV, figs. 1, 1*a*–*c* ; Plate CXXV, figs. 1, 1*a*–*c* ; Plate CXXXVII, figs. 1, 1*a* ; text-fig. 62.

1888. *Pecopteris Daubreei* Zeiller, " Flore foss. terr. houil. de Commentry," pt. 1, *Bull. Soc. Ind. Min.*, ser. 3, vol. ii, livr. 2, p. 147, pl. xv, figs. 1–5.

1892. *Pecopteris* (*Asterotheca*) *Daubreei* Zeiller, " Bassin houil. et perm. de Brive," fasc. 2, " Flore Foss.," *Études Gîtes Min. France*, p. 18, pl. iv, figs. 1–4.

1906. *Pecopteris* (*Asterotheca*) *Daubreei* Zeiller, " Bassin houil. et perm. de Blanzy et du Creusot," fasc. 2, " Flore Foss.," *Études Gîtes Min. France*, p. 40, pl. ix, figs. 1–4.

1901. *Cyathocarpus Daubreei* De Stefani, " Flore Carb. e Perm. della Toscana," p. 20, pl. vii, figs. 7, 8 ; pl. i, fig. 5 (*R. Ist. Studi sup. prat. e perfez. in Firenze*).

1834. *Pecopteris aspidioides* Brongniart (*non* Sternberg), " Hist. des végét. foss.," p. 311, pl. cxii, fig. 2.

Description.—Frond very large, quadripinnatifid or perhaps quadripinnate in basal region. Main rachis 2·5 cm. or more in breadth. Primary pinnæ touching each other laterally or overlapping, alternate, oval-linear, broadest about the middle and contracting somewhat suddenly into a sharp point, rachis straight, attaining a width of 5 mm. or more, apiculate. Secondary pinnæ alternate, free, touching laterally or margins overlapping, contracted at base, widest part about or slightly above the middle and somewhat suddenly contracting towards a point and terminating in a small blunt lobe. The higher-situated secondary pinnæ are of almost equal width till near the apex, where they gradually contract into a somewhat sharp point. Tertiary pinnæ on lower region of frond assume the form of elongated crenate pinnules which may possibly become quadripinnate.

Pinnules alternate ; on the middle secondary pinnæ almost at right angles to the rachis, on the higher-situated pinnæ more or less oblique to rachis, two to four times longer than broad, according to position of the pinnæ on the frond that bears them ; oblong, with straight, slightly convex margins and bluntly rounded apices, attached to the rachis by the broad base, free, sometimes slightly contracted at base or slightly united to each other and decurrent ; upper surface covered with short fine adpressed hairs which, when preserved, obscure the nervation. On the tertiary pinnæ the pinnules are confluent and are only individually indicated by their rounded apices, which form a crenate margin to the pinnæ.

Nervation observable only on the upper surface of the pinnules when the villose covering has been removed, but distinct on lower surface. Median vein extending to or near to the apex where it forks, straight or slightly decurrent, lateral veinlets departing at an open angle, most usually only once divided near their base; in the larger pinnules the upper arm of the fork frequently again divides. In the confluent pinnules the lateral veinlets are undivided. In the small pinnules on the uppermost secondary pinnæ the lateral veinlets are also sometimes simple.

Fructification.—The synangia form two rows on the pinnule, one row on each side of the median vein. The synangia appear to be usually formed of four sporangia, rounded at base with a pointed apex. The surface of the synangia has a striated appearance "as if the sporangia which form them had likewise a covering of hairs." *

Remarks.—The fronds of *Asterotheca Daubreei* must have been of very large size, and not only the form of the secondary pinnæ, but also that of the pinnules, varies on different regions of the frond.

Fig. 1, Pl. CXXIV, gives a portion of a large specimen which shows parts of three parallel primary pinnæ, none of which is complete at the base, but the one seen on the right side of the figure is almost complete at its upper end.

The primary pinnæ overlap considerably and their apiculate rachis is about 5 mm. in breadth. On the secondary pinnæ the shortest pinnules are situated at the base. These as traced upwards gradually increase in length for a distance of about two-thirds the length of the pinnæ.† From this point they decrease somewhat suddenly in length and the pinna terminates in a point. As the secondary pinnæ are traced upwards the pinnules become of more equal length, and the pinnæ towards the apex of the frond become linear-lanceolate and finally linear.‡

On the lower pinnæ of fig. 1, Pl. CXXIV, the pinnules are oblong, and the larger are about 9 mm. in length and 2·75 mm. to 3 mm. in breadth. On the anterior side they are more or less oblique to the rachis, but on the posterior side they may stand at almost right angles or become slightly oblique. They are attached to the rachis by the whole width of their base. Their posterior margin is sometimes slightly decurrent, while the anterior margin has a slight basal sinus. On all the pinnæ of this specimen, even on the linear secondary pinnæ near the apex, the pinnules are free or only very slightly connected by the posterior basal decurrence. It is only on the secondary pinnæ at the extreme apex of the primary pinnæ that they become confluent. At the apex also of the secondary pinnæ holding lower positions, very little union takes place between the pinnules; they may be slightly connected at their base, but their individuality remains distinct.

The villose covering on the pinnules of this specimen has mostly been removed or imperfectly preserved, the nervation is therefore sometimes shown on their upper surface, as seen at figs. 1*a* and 1*b*, which are enlarged two times. To show the nervation more distinctly, a pinnule is enlarged four times at fig. 1*c*. In the larger

* ZEILLER, "Flore foss. bassin houil. et perm. de Brive," p. 19.

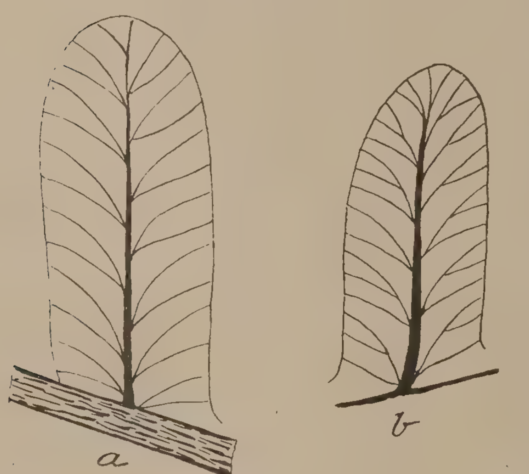
† *Cf.* ZEILLER, "Flore foss. bassin houil. et perm. de Brive," pl. iv, fig. 1.

‡ *Cf.* ZEILLER, "Flore foss. bassin houil. et perm. de Blanzy et du Creusot," pl. ix, fig. 1.

pinnules of this example the upper arm of the lateral veinlets frequently again divides, as seen in the text-fig. 62, *b*.

On the specimen given on Pl. CXXIII, fig. 1, the pinnules are more closely placed and broader in proportion to their length than those on the example just described (Pl. CXXIV, fig. 1). The basal secondary pinnæ have also more equal-sized pinnules, though their widest part is about two-thirds their length above the base. The villose covering on the pinnules has almost entirely been removed, as it has on almost all our specimens of *Asterotheca Daubreei*, though here and there its remains can be detected. Three pinnules are enlarged three times at fig. 1*a*, Pl. CXXIII. From two of these the villose covering has been entirely removed and they distinctly show the nervation. Here the upper arm of the forked lateral veinlets is frequently seen to divide. On pinnæ holding a middle or sub-basal position on the frond, a position probably held by this and the previously described example, a dichotomy of the upper arm of the lateral veinlets seems to have been a more or less constant occurrence.

The form of the secondary pinnæ seen on the specimen given on Pl. CXXIII, fig. 2, is very characteristic of secondary pinnæ from the middle region of the frond, where their greatest width is attained about two-thirds the length of the pinna from its base. The pinnules then decrease somewhat quickly in length and the pinna ends in a blunt point. The specimen also shows the characteristic punctate rachis. Two pinnules enlarged seven times are given at text-fig. 62. That at *a* has dichotomously-divided lateral veinlets, while on that at *b* the upper arm of the fork occasionally divides twice. In *a* the median vein joins straight on to the rachis, while in that at *b* it is slightly decurrent.



TEXT-FIG. 62.—*Asterotheca Daubreei* Zeiller sp. Two pinnules enlarged seven times to show the nervation.

The apex of a primary pinna is given natural size at fig. 3, Pl. CXXIII. The complete specimen, though it does not show the base of the pinna, is 19 cm. in length. On the lowest secondary pinna preserved on this example the pinnules appear to be free or only connected by their slightly decurrent bases. They are 6 mm. in length and about 2·50 mm. in breadth at the base. The pinnæ on this specimen are of almost equal width for about two-thirds of their length, when they gradually narrow and terminate in a lanceolate point. They are slightly distant and do not touch laterally. As traced towards the apex of the primary pinna, the secondary pinnæ decrease in length and the pinnules in size. On the pinnæ near the apex the small pinnules become united to each other more and more, and finally the apical pinnæ assume the form of pinnules. On account of the presence of the villose covering on the pinnules very few of them show their nervation. It shows, however, that in the pinnules on the lower pinnæ of the specimen the lateral veinlets divide only once. while in the small pinnules situated on the secondary pinnæ near the apex they are undivided.

On the specimen given natural size on Pl. CXXXVII, fig. 1, of which a small fragment of the punctate rachis is seen at the upper corner of the figure, the pinnules are decurrent and united to each other by the narrow point of the decurrent extension of the pinnule. The villose covering has been entirely removed from the surface of the pinnules, which thus show their nervation distinctly. The lateral veinlets appear in all the pinnules to be divided only once. The linear-lanceolate form of the secondary pinnæ seems to indicate that this specimen had occupied a position on the primary pinna above its middle region. None of our specimens shows the tertiary pinnæ, but this condition has been figured and described by Zeiller.* The pinnules are confluent and are individually indicated by their rounded apices, which form a crenate margin to the pinna.

The only fertile British specimen yet found is given natural size on Pl. CXXV, fig. 1. The rachis is densely apiculate and in its lower part is 5 mm. in breadth. The lower pinnæ are lanceolate and the upper linear-lanceolate. The uppermost seven pairs of alternate secondary pinnæ preserved on the fossil are sterile, while all the lower ones are fertile. The sterile pinnæ are very similar in form and size to those seen at fig. 3, Pl. CXXIII, and a part of one of them from the specimen given on Pl. CXXV, fig. 1, is enlarged three times at fig. 1*a*. The lateral veinlets seem to have been divided only once, as seen in the pinnule enlarged seven times at fig. 1*c*. The small close hairs on the surface of the pinnules have been almost entirely destroyed and only a few small imperfect patches remain on a few of the pinnules. All the pinnules of the lower secondary pinnæ are fertile except two or three pairs of very small pinnules which terminate the pinnæ. On the higher-placed fertile pinnæ a gradually increasing number of sterile pinnules appear on their apical portions until the whole pinna becomes sterile.

The position of the synangia is indicated on the upper surface of the pinnules, which have a dense villose covering, by little elevations as seen at fig. 1*b*.

From *Asterotheca oreopteridia* Schlotheim sp., *Asterotheca Daubreei* is easily distinguished by its apiculate rachis and the villosity on the upper surface of the pinnules, but this sometimes has been shed or not preserved, though usually some patches of it remain on a few of the pinnules. It differs also in the widest part of the secondary pinnæ, being about two-thirds the length of the pinna from its base.

Pecopteris densifolia Göppert sp.,† a species not recorded from Britain, has some resemblance to *Asterotheca Daubreei*, but the pinnules have not a villose surface and the rachis is only sparsely apiculate.

* "Bassin houil. et perm. de Blanzy et du Creusot," pl. ix, figs. 2, 2*a*.

† *Cyatheites densifolia* Göppert, "Foss. Flora d. Perm. Form." (*Palaeontographica*, Band xii), p. 120, pl. xvii, figs. 1, 2; *Pecopteris densifolia* Zeiller, "Flore foss. terr. houil. de Commentry," p. 152, pl. xvi, figs. 1–4.

Asterotheca lepidorachis also differs in the surface of the pinnules being smooth, not villose, as in *Asterotheca Daubreei.*

Distribution.—*Asterotheca Daubreei* Zeiller sp. is not common, and has hitherto been found in Britain only in the Radstock Group.

RADSTOCKIAN SERIES.

RADSTOCK GROUP.

Horizon: ?. *Localities:* Radstock, Somerset; Wellsway Pit, Radstock; Camerton, 2 miles north of Radstock.

Asterotheca Lamuriana Heer sp.

Plate CXXVI, figs. 1, 1*a*, 1*b*, 2, 2*a*, 2*b*.

1865. *Pecopteris* Heer, "Urwelt der Schweiz," p. 13, fig. 12.
1872. *Pecopteris Lamuriana* Heer, "Monde primitif de la Suisse," p. 15, fig. 12.
1876. *Alethopteris Lamuriana* Heer, "Flora foss. Helv.," p. 32, pl. xii, figs. 6, 7.
1884. *Pecopteris Lamuriana* Zeiller, "Flore de la Grand'Combe," *Bull. Soc. géol. France*, ser. 3, vol. xiii, p. 139.
1890. *Pecopteris Lamuriana* Grand'Eury, "Géol. et paléont. du bassin houil. du Gard," p. 272.
1907. *Pecopteris Lamuriana* Sterzel, "Karbon-u. Rothliegendfloren im Grossherzogtum Baden," *Mitt. badisch. geol. Landesanst.*, Band v, p. 673, pl. lii, figs. 1, 2; pl. liii, figs. 1, 1*a*–1*c*; pl. liv, figs. 1, 1*a*.

Description.—Frond very large, quadripinnate. Main rachis attaining a width of 1·5 cm. or more, densely apiculate. Primary pinnæ overlapping, rachis 6 mm. or more in breadth, apiculate. Secondary pinnæ free or touching laterally, alternate, linear-lanceolate, slightly narrowed at base and gradually narrowing from about their middle upwards and terminating in a lanceolate point with a blunt terminal lobe; rachis straight. Tertiary pinnæ close or more or less distant, alternate, linear, and ending in a blunt point; the uppermost gradually assume the form of oblong or elongated entire pinnules; rachis straight. Pinnules small, alternate, with slightly convex margins; on the pinnæ towards the base of the frond, 2 mm. to 3 mm. in length and about 1·5 mm. to 2 mm. in breadth, free, sometimes separated by a short space, broadly oblong, with lower angles slightly rounded and attached to the rachis by a broad base; on the upper pinnæ the small pinnules are more or less united to each other and form a crenulate margin to the pinnæ.

Nervation: the lateral veinlets in the free pinnules on the basal pinnæ dichotomize once, in the other pinnules they are undivided. Fructification borne on the tertiary pinnæ situated on the central portion of the secondary pinnæ; the basal and terminal tertiary pinnæ are sterile. Synangia usually composed of five sporangia arranged in the form of a small five-rayed star.

Remarks.—Of *Asterotheca Lamuriana* Heer sp. the only two British specimens I have seen are those given on Pl. CXXVI, figs. 1, 2. Although the fronds must have been of large size, hitherto only fragmentary examples of the species seem to have been discovered.

On Pl. CXXVI, fig. 1 is the impression of a fragment of the main rachis of the frond *c*. It is 1·5 cm. in breadth and densely apiculate. It gives off a primary pinna, of which the apiculate rachis is 6 mm. in breadth. The breadth of the main rachis shows that the frond must have attained to a considerable size.

Towards the upper margin of the figure a fragment of another primary apiculate pinna-rachis is seen to give off several incomplete secondary pinnæ. Those lettered *a* show their upper surface, while those lettered *b* exhibit their under surface. These latter have evidently been the alternate pinnæ which sprang from the left side of the rachis, but by some means have been bent back and now occupy a position between the pinnæ springing from the right side of the rachis, some of them being organically connected with it. The pinnules on the tertiary pinnæ of this example are all more or less united to each other, and this seems to have been the case on the greater portion of the frond.

Part of a secondary pinna, as well as the alternate tertiary pinnæ, is given enlarged two times at fig. 1*a*. The tertiary pinnæ at the base of the secondary are shorter than those above them, which increase in length as traced upwards; thus the broadest part of the secondary pinnæ is in their central region, whence the tertiary pinnæ gradually decrease in length.

The tertiary pinnæ are not contracted at their base but are of almost equal width till near their apex, which terminates very bluntly. The small confluent pinnules are convex and their median vein gives off a few undivided lateral veinlets. This is seen at fig. 1*b*, which is enlarged six times.

On the specimen given at fig. 2, Pl. CXXVI, a number of secondary pinnæ are seen; the position of these in relation to the rachis which passes up the figure is probably accidental, since no organic connexion can be observed.

Towards the base of the figure some fertile secondary pinnæ occur. A part of two of these is enlarged two times at fig. 2*a*. The tertiary pinnæ have here almost assumed the form of free, elongated pinnules, though at their base a few of the bluntly rounded apices of the component pinnules can be distinctly observed. These basal pinnules appear to be always sterile, and the fructification seems to be restricted to the upper portion of the tertiary pinnæ, from which all trace of the marginal crenulation has disappeared. On the upper third of the secondary pinnæ, the tertiary pinnæ have assumed the form of sterile tongue-shaped pinnules with entire margins. This is well seen on the pinnæ enlarged two times at fig. 2*a*.

A pinnule from the fragment of the pinna indicated by an arrow on fig. 2 is enlarged about seven times at fig. 2*b*. This shows the straight median vein extending to the blunt apex of the pinnule and giving off alternate simple veins which depart at about an angle of 45°. On both the specimens figured here, wherever the nervation is visible, the lateral veinlets are invariably undivided.

All the fertile pinnæ occurring on fig. 2 show their upper surface, but the impress of the synangia shows their form and position on the pinnule distinctly in some cases. A single row of stellate synangia is situated on each side of the rachis of the pinnule-like tertiary pinnæ and placed equidistant from it and the margin, but frequently the two rows of synangia occupy the whole of the under side of the pinnule. The synangia are usually formed of five very small sporangia, and the complete synangium measures only 1 mm. in diameter. They may not, however, have reached maturity.

A portion of a primary pinna, presumably from a lower region of the frond than those shown on Pl. CXXVI, is figured by STERZEL.* This shows the quadripinnate condition of the frond where the tertiary pinnæ end in a lanceolate blunt-pointed terminal lobe and bear oval, sessile, somewhat distant pinnules attached to the rachis by a broad base whose lateral veinlets all divide into two arms.

Distribution.—Asterotheca Lamuriana is very rare in Britain, only a single specimen having been found at each of the two undernoted localities.

RADSTOCKIAN SERIES.

RADSTOCK GROUP.

Horizon: ?. *Localities:* Ludlow's Pit, Radstock, Somerset; Braysdown Colliery, near Radstock.

Genera **Scolecopteris** Zenker and **Acitheca** Schimper.

SCOLECOPTERIS Zenker.

1837. *Scolecopteris* Zenker, "*Scolecopteris elegans* Zenker. Ein neues fossiles Farrngewächs mit Fructificationen," *Linnaea*, p. 509, pl. x.
1869. *Scolecopteris* Schimper, "Traité de paléont. végét.," vol. i, p. 680.
1874. *Scolecopteris* Strasburger, "Ueber *Scolecopteris elegans* Zenker, einen fossilen Farn aus der Gruppe der Marattiaceen," *Jenaische Zeitschr.*, Band viii, p. 81, pls. ii, iii.

SCOLECOPTERIS Zenker, in which is included ACITHECA Schimper.

1883. *Scolecopteris* Stur, "Zur Morph. u. System. d. Culm-und Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 720 (88).
1885. *Scolecopteris* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 190.
1888. *Scolecopteris* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 39.
1888. *Scolecopteris* Zeiller, "Flore foss. terr. houil. de Commentry," *Bull. Soc. Ind. Min.*, ser. 3, vol. ii, livr. 2, p. 98.
1890. *Scolecopteris* Zeiller, "Flore foss. bassin houil. et perm. d'Autun et d'Épinac," fasc. 2, pt. 1, *Études Gîtes Min. France*, p. 24.
1891. *Scolecopteris* Kidston, "On the Fructification, etc., of Carboniferous Ferns," *Trans. Geol. Soc. Glasgow*, vol. ix, p. 19.
1891. *Scolecopteris* Solms-Laubach, "Fossil Botany," p. 143.

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* *Loc. cit.*, pl. liii, fig. 1.

1899. *Scolecopteris* Potonié, "Lehrb. d. Pflanzenpal.," p. 97.
1900. *Scolecopteris* Zeiller, "Éléments de paléobotanique," p. 60.
1900. *Scolecopteris* Scott, "Studies in Fossil Botany," p. 254; 2nd ed., p. 282, 1908; 3rd., pt. 1, p. 256, 1920.
1910. *Scolecopteris* Seward, "Fossil Plants," vol. ii, p. 401.
1921. *Scolecopteris* Gothan in Potonié, "Lehrb. d. Paläobot." (Zweite Auflage), p. 63.

Acitheca Schimper.

1879. *Acitheca* Schimper in Zittel, "Handbuch d. Palaeont.," Abth. 2, Palaeophytologie, p. 91.
1901. *Acitheca* De Stefani, "Flore Carbonifere e Permiane della Toscana," p. 21 (*R. Ist. Studi sup. prat. e perfez. in Firenze*).
1883. *Pecopteris polymorpha* Renault, "Cours de botan. foss.," vol. iii, p. 116, pl. xx, figs. 1–10. (Gives detailed description of the fructification.)

So far as I am aware, all palæobotanists, with the exception of De Stefani (*loc. cit.*), have for forty years included *Pecopteris polymorpha*, of which the fructification was first described by Grand'Eury in 1877,* in the genus *Scolecopteris* Zenker, though in 1879 Schimper (*loc. cit.*) founded the genus *Acitheca* for its reception. This genus is very seldom mentioned and seems almost to have passed out of memory.

A few years after Schimper founded his genus *Acitheca*, Renault in 1883 (*loc. cit.*) gave a detailed account of the synangia of *Pecopteris polymorpha* Brongniart (the type of the genus *Acitheca*), but does not refer it to that genus. It is given by Zeiller, however, as a synonym of *Scolecopteris* † without comment. It appears to me that the claim for including *Pecopteris polymorpha* in *Scolecopteris* rather than in Schimper's *Acitheca* must be reconsidered, for I agree with Schimper in excluding it from the former genus.

In the references given above, the first list includes those which refer exclusively to *Scolecopteris* Zenker; in the second list the fructification of *Pecopteris polymorpha* is referred to *Scolecopteris*; while in the third list, *Pecopteris polymorpha* is placed in Schimper's genus *Acitheca*, or to that species alone does the reference apply.

It is necessary, therefore, carefully to consider the original generic descriptions of *Scolecopteris* Zenker and *Acitheca* Schimper, especially in the light of Renault's detailed description of the synangia of Schimper's genus.

Scolecopteris Zenker.

Description.—Synangia formed of four to five exannulate sporangia, ovate, tapering upwards and ending in a point, free, except at their base, where they are united to each other and attached to the apex of a short pedicel-like receptacle which has a central vascular strand. The synangia stand at right angles to the lower surface of the pinnules and are arranged in two rows, one row on each side of the midrib. The spores were probably shed through a longitudinal cleft on the ventral surface

* "Flore Carbonifère du Dépt. de la Loire et du Centre de la France," p. 74, pl. viii, figs. 10, 11.

† "Flore foss. bassin houil. de Valenciennes," p. 39.

of the sporangia. The margins of the fertile pinnules are recurved, and partly cover the synangia.

Remarks.—This genus was founded by ZENKER in 1837 (*loc. cit.*) for fructifications contained in a silicious specimen from the neighbourhood of Chemnitz, and was more fully investigated by STRASBURGER in 1874 (*loc. cit.*).

At text-fig. 63 a transverse section of a fertile pinnule of *Scolecopteris elegans* is given to show the small pedicel on which the synangia are placed, and also the recurved margins of the pinnule. At text-fig. 64 a longitudinal section of a single synangium is more highly enlarged.

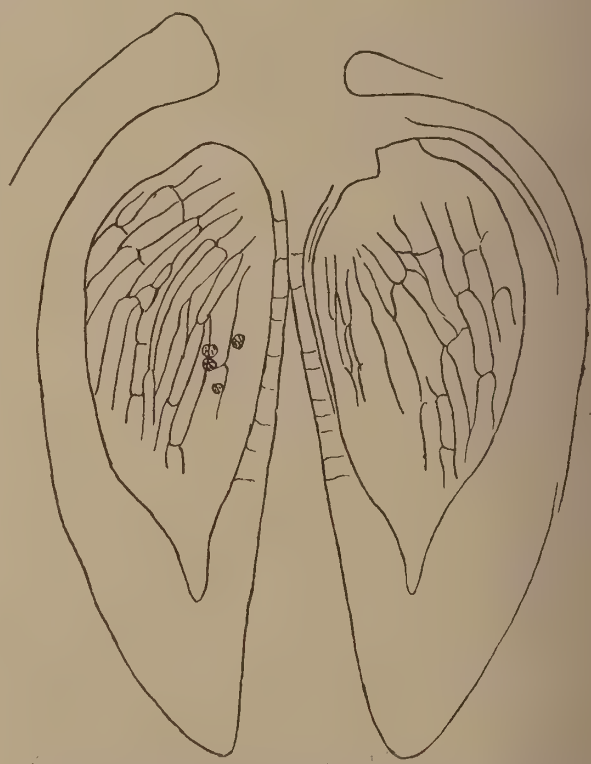
TEXT-FIG. 63.—*Scolecopteris elegans* Zenker. Transverse section of a fertile pinnule. Enlarged ten times. After STRASBURGER.

The sporangia forming the synangia of *Scolecopteris* are similar in general form to those of *Asterotheca*, and though they are longer than the sporangia of that genus they are not much longer than those of *Asterotheca oreopteridia* as figured by RENAULT * (see text-fig. 66).

The sporangia of *Scolecopteris* are free except at their base, where they are united to each other, and the resulting synangium sits on the top of a short pedicel. In fact, the genus *Scolecopteris* might be described as a pedicellate *Asterotheca*, the presence of the pedicel being the chief character which separates the two genera.

The presence of a pedicel also separates *Scolecopteris* from *Acitheca* Schimper, in which, in addition to the sporangia being attached laterally to a column or receptacle by their basal portion, they are sessile and united to the surface of the pinnule by a broad base. They also end in long bristle-like points (text-fig. 65).

Scolecopteris differs, then, from *Asterotheca* in the presence of a column, with the summit of which the sporangia are united.



TEXT-FIG. 64.—*Scolecopteris elegans* Zenker. Synangium in longitudinal section. Enlarged 100 times. After STRASBURGER.

ACITHECA Schimper.

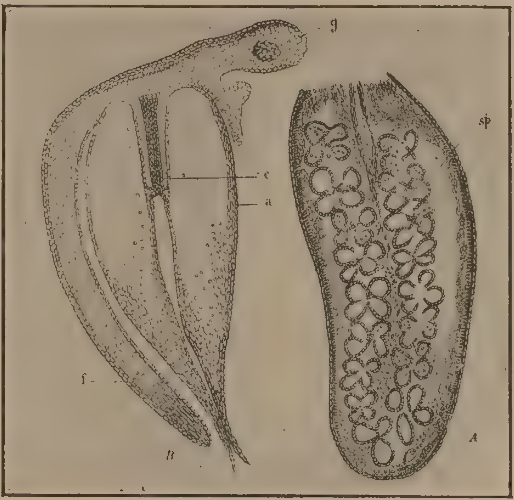
Description.—Synangia sessile, usually formed of four (rarely three or five) sporangia, placed on the pinnule in two rows, one row on each side of the midrib. Sporangia exannulate, long, rounded at

* "Cours de botan. foss.," vol. iii, pl. xix, fig. 9.

base and terminating in a sharp bristle-like point, upper two-thirds of their length free, basal third united to a central column. The synangia thus formed are sessile and attached by their broad base perpendicularly to the lower surface of the pinnule.

The column or receptacle into which a vascular bundle extends has four plates or wings to which the sporangia are united. Dehiscence takes place through a vertical cleft which passes up the ventral surface of the sporangia. The margins of the pinnules are recurved and almost cover the synangia.

Remarks.—To Renault we are indebted for a detailed description of the synangia of *Pecopteris polymorpha* Brongniart, which forms the type of Schimper's genus *Acitheca*. The outer and lateral walls of the sporangia are formed of several rows of thick cells, but the ventral side, which is united to the column, is composed of a layer of delicate cells which at maturity ruptured longitudinally and allowed the spores to escape. A slightly reduced copy of Renault's original figure of the synangia of *Pecopteris polymorpha* Brongniart, seen at text-fig. 65, A, gives a section of a fertile pinnule passing horizontally along its lower surface. It shows the synangia *sp.*, composed almost invariably of four sporangia, whose inner walls, which join on to the arms of the stellate central column, are formed of delicate cells. At B of the same text-fig. a longitudinal section of a synangium is seen. At *a* is the outer thick wall of the sporangium, at *c* the central column to whose wings the sporangia are attached. At *f* is the recurved limb of the pinnule, and at *g* the median vein seen in transverse section.



Text-fig. 65.—*Acitheca polymorpha* Brongniart sp. A, section of fertile pinnule parallel with surface passing through the basal portions of the synangia. B, longitudinal section of a synangium. After Renault; reduced from Stur.

The most interesting point in the structure of the synangium of *Pecopteris polymorpha* is the sessile mode of its attachment to the frond. Here, although the sporangia are attached to a column, it does not act as a pedicel to the synangium, but only as an additional support to the sporangia, probably necessitated on account of their unusual length. Notwithstanding that the synangium of *Pecopteris polymorpha* has frequently been described as pedicellate, it is really sessile, being directly attached to the limb of the pinnule by its base. The column is contained entirely within the synangium. For this fructification, as distinguished from *Scolecopteris* Zenker, where the synangia are situated on the top of a short pedicel, Schimper founded his genus *Acitheca* (*loc. cit.*).

The important differences seen in the structure of the synangia of *Pecopteris polymorpha* Brongniart, when compared with those of *Scolecopteris elegans* Zenker.

appear to me fully to justify SCHIMPER in creating the genus *Acitheca* for the reception of BRONGNIART'S species, in which genus it is here placed.

Affinities of genera under discussion. When dealing with the genus *Asterotheca* (*ante*, p. 528) we left its affinities an open question, since the matter could be more conveniently considered in conjunction with the allied genera *Scolecopteris* and *Acitheca*.

These three genera, as well as other genera of supposed ferns with exannulate sporangia, were generally believed to have affinities with the Marattiaceæ and were classified as such; but as it is now known that some of the supposed Marattaceous genera are referable to the Pteridosperms, the affinities of other supposed Marattiaceous ferns from the Carboniferous Formation demand reconsideration.

If we compare the synangia of *Acitheca* Schimper with the synangia of *Telangium Scotti* Benson,* we cannot fail to observe the similarity in the structure of their synangia. Their differences are of detail and not of type, and the absence or presence of the limb of the pinnule in association with the fructification is of no importance, so far as the question of affinity is concerned, for synangia having a type of structure similar to those of *Telangium* occur on the pinnules of *Dicksonites Pluckeneti*, an undoubted Pteridosperm. The same comparison holds good for other species of *Telangium*.

For the purpose of comparison a copy of RENAULT'S figure of a vertical section through two synangia of *Asterotheca oreopteridia* Schlotheim sp. is given at text-fig. 66. These are usually described as attached around a very slightly elevated receptacle, but the figure represents the synangia as directly situated on the lateral veinlets *a* as in *Dicksonites*.

TEXT-FIG. 66.—*Asterotheca oreopteridia* Schlotheim sp. Longitudinal section through two synangia enlarged forty times. After RENAULT.

In *Scolecopteris* Zenker the synangia terminate a short pedicel (text-figs. 63 and 64), while in *Acitheca* the synangia are sessile (text-fig. 65). In all these genera there is a similar type of sporangium or microsporangium, and probably all dehisce in the same way. The individual differences they show are clearly only variations in detail, not in type of structure.

In *Acitheca* the individual sporangia agree so well with the microsporangia of *Telangium*, that the affinities of *Acitheca* seem to me to be Pteridospermous. If, then, this opinion as to the systematic position of *Acitheca* Schimper be correct, I do not see on what ground *Asterotheca* Presl and *Scolecopteris* Zenker can be excluded from the Pteridosperms.

It would therefore appear that the evidence in support of the occurrence of Marattiaceous Ferns in Carboniferous times rests on supposition rather than on

* "*Telangium Scotti*, a new species of *Telangium* (*Calymmatotheca*) showing structure," *Ann. of Bot.*, vol. xviii, p. 161, pl. xi, 1904.

satisfactory proof. This statement may be thought too strong, but what has been learnt in regard to Pteridosperm microsporangia has undoubtedly weakened the grounds on which the belief in the existence of Carboniferous Marattiaceous Ferns was founded.*

Acitheca polymorpha Brongniart sp.

Plate CXXVIII, figs. 1, *1a*; Plate CXXIX, figs. 1, *1a*, *1b*, 2, *2a*, 3, 4; Plate CXXX, figs. 3, *3a*, 4, *4a*; text-figs. 67–69.

1828. *Pecopteris polymorpha* Brongniart, "Prodrome," p. 56.
1834. *Pecopteris polymorpha* Brongniart, "Hist. des végét. foss.," vol. i, p. 331, pl. cxiii, figs. 1–6.
1877. *Pecopteris polymorpha* Grand'Eury, "Flore carbon. du Dépt. de la Loire," *Mém. Acad. Sci. Paris*, vol. xxiv, no. 1, p. 74, pl. viii, figs. 10, 11.
1880. *Pecopteris polymorpha* Zeiller, "Végét. foss. du terr. houil.," p. 91, pl. cxix, figs. 1–3. (*Expl. Carte géologique de la France*, vol. iv.)
1883. *Pecopteris polymorpha* Renault, "Cours de botan. foss.," vol. iii, p. 116, pl. xx, figs. 1–10.
1888. *Pecopteris* (*Scolecopteris*) *polymorpha* Zeiller, "Flore foss. terr. houil. de Commentry," *Bull. Soc. Ind. Min.*, ser. 3, vol. ii, livr. 2, p. 155, pl. xvi, figs. 5, 6.
1893. *Pecopteris polymorpha* Potonié, "Flora d. Rothl. von Thüringen," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft 9, Theil 2, p. 67, pl. vii, figs. 8, 9.
1912. *Pecopteris polymorpha* Vernon, "Geology and Palæontology of Warwickshire Coalfield," *Quart. Journ. Geol. Soc.*, vol. lxviii, p. 638, pl. lix, fig. 8.
1890. *Pecopteris* (*Scolecopteris*) *polymorpha* Zeiller, "Flore foss. bassin houil. et perm. d'Autun et d'Épinac," *Études Gîtes Min. France*, p. 59, pl. viii, fig. 8.
1907. *Pecopteris* (*Scolecopteris*) *polymorpha* Sterzel, "Karbon-u. Rothlfl. im Grossherzog. Baden," *Mitteil. badischen geol. Landesanst.*, Band v, Heft 2, p. 481, pl. xx, figs. 1, *1a*; pl. xxi, figs. 1, *1a*, *1b*; pl. xxii; pl. xxiii, figs. 1, *1a*, 2; pl. xxiv; pl. xxv, fig. 1 at *a* on *1a*; pl. xxvi, figs. 1, 2, p. 534; pl. xxxv, fig. 1 at B; pl. xxxvi, fig. 1, A–B.
1893. *Pecopteris* (*Scolecopteris an Acitheca*) *polymorpha* Sterzel, "Flora d. Rothl. im Plauenschen Grunde bei Dresden," *Abhandl. k. sächs. Gesellsch. Wissensch.*, Band xix, p. 32, pl. iv, figs. 2–5.
1879. *Acitheca polymorpha* Schimper in Zittel, "Handb. d. Palaeont.," Abth. 2, Palaeophytologie, p. 91, fig. 66 (9–12).
1901. *Acitheca polymorpha* De Stefani, "Flora Carb. e Perm. della Toscana," p. 22, pl. v, figs. 2, 3 (*R. Ist. Studi sup. prat. e perfez. in Firenze*).
1883. *Scolecopteris polymorpha* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 124, text-fig. 21, p. 107.
1885. *Scolecopteris polymorpha* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 205, text-fig. 25, p. 198.
1888. *Scolecopteris polymorpha* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 39, fig. 25B.
1888. *Scolecopteris polymorpha* Schenk, "Foss. Pflanzenreste," p. 32, fig. 25.
1891. *Scolecopteris polymorpha* Solms-Laubach, "Fossil Botany," p. 145, fig. 13D.
1899. *Scolecopteris polymorpha* Potonié, "Lehrb. d. Pflanzenpal.," p. 97, fig. 76.
1921. *Scolecopteris polymorpha* Gothan in Potonié, "Lehrb. d. Paläobotanik" (Zweite Auflage), p. 63, fig. 51.

* Compare the discussion on this subject in Bower, "Origin of a Land Flora," pp. 520–524, 1908, where reliance was placed on *Ptychocarpus*, *Scolecopteris* (including *Acitheca*), *Asterotheca*, and *Danæites*.

1877. *Scolecopteris conspicua* Grand'Eury, " Flore carbon. du Dépt. de la Loire," p. 74, pl. viii, figs. 10, 11.
1883. *Hawlea Bosquetensis* Stur, " Morph. u. Syst. d. Culm-u. Carbonfarne," p. 54 (*loc. cit.*).
1885. *Hawlea Bosquetensis* Stur, " Carbon-Flora d. Schatzlarer Schichten," pp. 108 and 111 (*loc. cit.*).
1834. *Pecopteris Miltoni* Brongniart (*pars, non* Artis), " Hist. des végét. foss.," vol. i, p. 333, pl. cxvi, figs. 1–7 (*non* fig. 8).
1838. *Pecopteris Miltoni* Sternberg (*pars, non* Artis), " Versuch," ii, fasc. vii–viii, p. 151.
1876. Cf. *Cyatheites Miltoni* Heer (*pars*), " Flora foss. Helv.," p. 28, pl. ix.
1901. *Acitheca isomorpha* De Stefani (*pars*), " Flore Carb. e Perm. della Toscana," p. 24, pl. vi, figs. 3–5 (*loc. cit.*).

Description.—Frond of very large size, tripinnate in upper portion, quadripinnate at base. Main rachis 4 cm. or more in breadth, smooth or with fine longitudinal striations with occasionally a few scattered small apiculi. Primary pinnæ alternate, slightly oblique to rachis, linear-lanceolate, their margins slightly overlapping, attaining a length of 60 cm. ; rachis straight, smooth or with very fine longitudinal striations, and minutely punctate. Secondary pinnæ alternate, spreading out at almost a right angle or slightly oblique to rachis, linear-lanceolate, of almost constant width for two-thirds of their length, then gradually tapering upwards and terminating in an obtuse or sub-obtuse terminal lobe, attaining a length of 8 cm. or more ; rachis straight. Tertiary pinnæ alternate, linear-lanceolate, spreading out at almost right angles or slightly oblique to rachis, touching each other laterally, tapering gradually upwards from the base and terminating in an obtusely-pointed lobe and attaining a length of 4 cm. or more ; rachis straight.

Pinnules alternate, upright to rachis or slightly oblique, margins parallel and slightly convex, occasionally contracted a little near the apex, which is bluntly rounded, one and a half to three times longer than broad and may have a length of 1·5 cm. On the central region of the frond the pinnules are free and slightly contracted at base or slightly united to each other according to the position of the pinna on which they occur. The basal posterior pinnule is borne at the extreme base of the rachis. On the secondary pinnæ, holding upper positions on the primary pinnæ, the pinnules become smaller and more and more united to each other until the secondary pinnæ become pinnatifid and finally assume the form of simple elongated pinnules. Towards the base of the frond the larger pinnules become sinuous, then lobed, and finally take the form of lanceolate tertiary pinnæ which taper gradually from the base to the apex and bear small, somewhat convex pinnules, the larger of which are about 5 mm. in length and 3 mm. to 3·5 mm. in breadth, free on the basal portion of the tertiary pinnæ, but become united to each other on its upper part.

Nervation generally distinct. Median vein thick, not decurrent at base, extending to near the apex, where it divides into two arms which again bifurcate. The lateral veinlets are given off at a wide angle and dichotomize immediately above the base. Each arm again divides and, passing outwards with a low curve, meets the margin of the pinnule at an open angle ; the upper lateral veinlets may have three arms, while those at the apex have only two. In the small pinnules of the tertiary pinnæ the veinlets have two, more rarely three arms.

The fertile pinnules have much-recurved margins and are confined to the basal region of the secondary pinnæ, whose apical portion remains sterile. Sporangia exannulate, coriaceous, fusiform, terminating in a bristle-like point, 2·5 mm. to 4 mm. in length, basal portion of sporangia united to a central column, upper two-thirds free. The synangia thus formed are usually composed of four, rarely of five sporangia, are sessile and attached by a broad base to the pinnule, where they form two rows, one on each side of the median vein, and normally hold a position at right angles to the lower surface of the pinnule. Dehiscence takes place through a longitudinal cleft on the inner surface of the sporangia. Spores very numerous, small, 30 μ in diameter.

Remarks.—Several specimens of *Acitheca polymorpha* Brongniart sp. are given on the plates in illustration of the polymorphic character of the species.

A portion of a primary pinna from probably the middle region of the frond is shown natural size at fig. 1, Pl. CXXIX. This example illustrates what has come to be regarded as the "typical" form of the species. In the part of the specimen figured, a fragment of the rachis of the primary pinna is seen at the upper end. It is rather over 5 mm. in breadth, is smooth, and has a very few fine striations. The secondary pinnæ are alternate, placed close to each other and touch laterally, though they scarcely overlap. Their lower third is of almost equal width, but from that point they gradually taper upwards. The pinnules are short, oblong, with straight sides and obtusely rounded apices. Their recurved margins give a slight convexity to the pinnule. The posterior basal pinnule is placed on the rachis so close to its base that it sometimes appears as if it sprang from the angle formed by the union of the secondary and primary pinnæ. The median vein is thick, and the lateral veinlets spring from it at an open angle, bend quickly outwards, and meet the margin at almost right angles. The first dichotomy of the lateral veinlets occurs immediately above their base, and the resulting arms usually undergo a second dichotomy; some may have only three divisions, while those at the apex of the pinnule have only two arms. A few pinnules are enlarged three times at figs. 1*a* and 1*b*; one is enlarged six and a half times at text-fig. 67 to show the nervation.

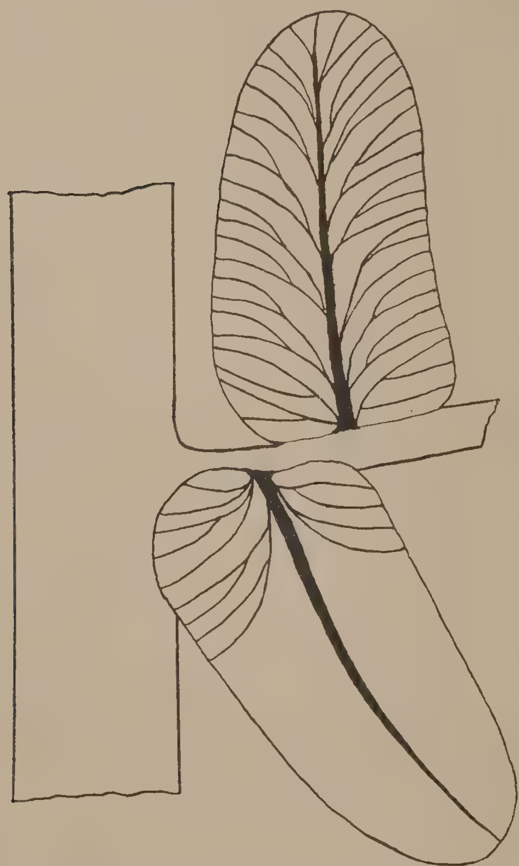
TEXT-FIG. 67.—*Acitheca polymorpha* Brongniart sp. Pinnule enlarged six and a half times to show nervation and cellular papillosity of the upper surface.

When the upper surfaces of the pinnules on this specimen are examined under a lens they are seen to be finely papillose. This appearance seems to be produced by a convexity of the cells forming the epidermis. It is not produced by small adpressed hairs, as on the pinnules of *Asterotheca Miltoni* and some other pecopteroid species. I have tried to represent their appearance at text-fig. 67.

A portion of another primary pinna is given natural size at fig. 4, Pl. CXXX, of which a small part is enlarged two times at fig. 4*a*.

At the left-hand bottom corner of fig. 4 the terminations of a few secondary pinnæ are seen. They end in a small oblong obtuse lobe. On this example the pinnules are mostly free and contracted at the base. When they are united to each other, it is only to a very short extent. The specimen also shows distinctly the position of the two basal pinnules, the posterior one being placed on the rachis close to its base, and is frequently slightly larger than the corresponding anterior basal pinnule. Two such pinnules are enlarged seven times at text-fig. 68, which shows these characters as well as the nervation. For this specimen I am indebted to Mr Robert Crookall, of Bristol.

Two secondary pinnæ from a specimen of which the finely striated rachis is about 0·8 mm. in breadth are given natural size at fig. 3, and some of the pinnules enlarged three times are seen at fig. 3*a*. A single pinnule is enlarged six and a half times at text-fig. 69 to show the nervation and slight union to each other. On this example some of the pinnules are slightly lobed or have sinuous margins. This specimen held a lower position on the frond than those already described. On still lower-situated primary pinnæ the pinnules become more and more distinctly lobed, and finally the pinnules assume the form of tertiary pinnæ, as seen on the specimen given natural size at Pl. CXXVIII. This example illustrates the quadripinnate condition of the frond. The lanceolate tertiary pinnæ taper gradually from the base upwards and end in an oblong terminal lobe similar to those seen on the lower corner of fig. 4, Pl. CXXX. The pinnules are short-oblong, free, sometimes slightly contracted at base, with rounded apex, not much longer than broad, and only become united to each other at the upper end of the pinnæ. The median vein is straight, thick, and not decurrent, the lateral veinlets appear to be only once divided, though one of the arms may divide again. The nervation, however, is rather obscure on our specimen and difficult to trace clearly except in a very few of the pinnules.



Text-fig. 68.—*Acitheca polymorpha* Brongniart sp. Pinnules enlarged seven times to show the nervation and position of the basal posterior pinnule on the rachis.

The rachis seen at the left side of the figure (Pl. CXXVIII, fig. 1), to which the secondary pinnæ have evidently been attached, is very minutely punctate.

On the specimen of *Acitheca polymorpha* figured by POTONIÉ * the rachis is also shown to be punctate.

On the tertiary pinnæ, towards the apex of the secondary pinnæ, the pinnules become more and more united till they form a crenate marginal band to the rachis of the pinnæ.

One of these tertiary pinnæ is enlarged three times at fig. 1*a*, Pl. CXXVIII, to show the blunt terminal lobe and the free pinnules at the base, which become united on the upper portion.

Some portions of fertile pinnæ are shown natural size on Pl. CXXIX, fig. 2, and a small part is enlarged two times at fig. 2*a*. The synangia are upright to the lower surface of the pinnules, and are so seen on our figure, where they appear as a fringe. Usually, however, they are displaced and lie horizontally on the surface of the pinnules. ZEILLER gives the length of the sporangia of *Acitheca polymorpha* Brongniart sp. as from 3–4 mm. On our example they are only about 2·5 mm. in length, but that they have not been fully developed is shown by the immature condition of the spores obtained from some sporangia. Fig. 3, Pl. CXXIX, shows the spore-contents of a sporangium enlarged twenty times. The spores are firmly united to each other and form a fusiform column, rounded at base and gradually tapering to the apex. A few spores enlarged two hundred and fifty times are given at fig. 4. They are immature and slightly deformed from mutual pressure, some being sub-hexagonal in form. They have a diameter of 30 μ.

TEXT-FIG. 69.—*Acitheca polymorpha* Brongniart sp. Pinnule enlarged six and a half times to show the nervation and a slight union to each other.

Professor PAUL BERTRAND has expressed to me his opinion that the specimens described by ZEILLER as the fructifications of *Dictyopteris Schuetzei*,† which he united later with *Dictyopteris Germari*,‡ are the synangial pinnules of *Acitheca polymorpha* Brongniart sp. in a peculiar bituminous condition of preservation. §

The species with which *Acitheca polymorpha* Brongniart sp. is most likely to be mistaken is *Asterotheca Miltoni* Artis sp., with which it has sometimes been confused. The pinnules of both undergo the same changes in form on corresponding parts of the frond. Though the two species have a strong superficial resemblance in the sterile condition, they are beyond all doubt specifically and generically distinct.

In the case of fragmentary and imperfectly preserved specimens which do not show the nervation it is sometimes very difficult to satisfactorily separate these two species.

* POTONIÉ, "Flora d. Rothl. von Thüringen," pl. viii, fig. 9.

† "Flore foss. terr. houil. de Commentry," pl. xxxi, figs. 2 and 4, 1888.

‡ *Linopteris Germari*, ZEILLER, "Flore foss. bassin houil. et perm. de Blanzy et du Creusot," p. 108.

§ *See also* BERTRAND, "Les fructifications de Neuroptéridées," *Ann. Soc. géol. du Nord*, vol. xlii, p. 132, pl. vi, fig. 7, 1913.

The following scheme arranged in tabular form shows the characters which distinguish *Acitheca polymorpha* from *Asterotheca Miltoni.* This table should be read in connexion with the figures given in the plates and in the text.

Acitheca polymorpha Brongniart sp.	*Asterotheca Miltoni* Artis sp.
Secondary pinnæ in upper portion taper to a point.	Corresponding pinnæ very blunt and obtuse.
Tertiary pinnæ tapering gradually from their base to their apex.	Tertiary pinnæ of almost equal width till near the apex, where they contract suddenly and end in an obtuse point.
Upper surface of pinnules smooth.	Upper surface of pinnules villose. (The small adpressed hairs on the surface of the pinnules of *Asterotheca Miltoni* are frequently not preserved; the pinnules then have a smooth surface. See *ante*, p. 541.)
Median vein of pinnules situated on central region of frond always straight and thick.	Median vein of pinnules from corresponding region of frond straight or slightly decurrent. Not so thick.
Median vein of small pinnules of quadripinnate condition of frond always straight.	Median vein of corresponding condition of frond always very decurrent.
Lateral veinlets of pinnules from central area of frond have four or five veinlets closely placed to each other and meet the margin at a wide angle.	Lateral veinlets of corresponding pinnules three times divided, more distant, and have a more oblique course to the margin of the pinnule.
Lateral veinlets of small pinnules in quadripinnate condition usually only once divided, rarely with three arms. Terminations of veinlets close to each other at margin of pinnules.	Lateral veinlets of corresponding pinnules, once divided, more distant, depart from the median vein at a more acute angle and take a more ascending course to the margin. Terminations of veinlets more distant and more oblique to margin of pinnule.
Fructification: the genus *Acitheca* Schimper.	Fructification: the genus *Asterotheca* Presl.

The separate points of difference that distinguish the two species may appear to be slight; but if they could be observed together in complete specimens the two plants could be readily separated. What difficulty there is in their identification lies in the imperfect material with which one has frequently to deal.

Eupecopteris pteroides Brongniart sp. is easily distinguished from *Acitheca polymorpha* by its very close and more-divided lateral veinlets, which ascend more directly to the margin of the pinnule. Also, the basal posterior pinnule is placed in the angle formed by the union of the secondary pinnæ with the rachis of the primary pinnæ, or is even placed on the rachis of the latter. It is also easily separated from *Asterotheca oreopteridia,* of which the lateral veinlets are more distant and more ascending, and most usually divided into only two arms, though rarely one of the arms may again divide.

As already mentioned (*ante*, p. 538), it appears to me that *Acitheca polymorpha* Brongniart sp. is much more probably a Pteridosperm than a Marattiaceous Fern, which it has been formerly regarded.

Distribution.—Acitheca polymorpha Brongniart sp. is rare in Britain, but has been recorded from the Radstock, Farrington and Keele Groups of the Radstockian Series, and from the Newcastle-under-Lyme Group of the Staffordian Series.

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon: ?. *Localities:* Radstock, Somerset; Braysdown Colliery, near Radstock; Camerton, 2 miles north of Radstock.

South Wales Coalfield.

FARRINGTON GROUP.

Horizon: No. 3 Llantwit Seam. *Locality:* Cross Inn, near Llantrisant, Glamorganshire (D. Davies).

Warwickshire Coalfield.

KEELE GROUP.

Horizon: ?. *Locality:* Foleshill Clay Pit, Coventry (R. D. Vernon).

STAFFORDIAN SERIES.

Forest of Dean Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: Coleford High Delf Coal. *Locality:* Drybrook Colliery, Drybrook, Gloucestershire (E. A. N. Arber).

Shrewsbury Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: Half-yard Coal. *Locality:* Hanwood Pit, midway between Hanwood and Cruckmeole, 4 miles south-west of Shrewsbury, Shropshire.

Somerset and Bristol Coalfield.

NEWCASTLE–UNDER–LYME GROUP.

Horizon : ?. *Localities :* Broad Oak Colliery, Pensford, 2 miles north of Clutton, Somerset (R. Crookall) ; Parkfield Colliery, near Pucklechurch, Gloucestershire (R. Crookall).

Genus **Ptychocarpus** Weiss.

1869. *Ptychocarpus* Weiss, "Foss. Flora d. jüngst. Steinkf. u. Rothl. im Saar-Rhein Gebiete," Heft 1, p. 94 (*K. Akad. d. Wissensch. Berlin*).
1874. *Ptychocarpus* Schimper, "Traité de paléont. végét.," vol. iii, p. 507.
1888. *Ptychocarpus* Zeiller, "Flore foss. terr. houil. de Commentry," *Bull. Soc. Ind. Min.*, ser. 3, vol. ii, livr. 2, p. 98.
1888. *Ptychocarpus* Zeiller, "Flore foss. bassin houil. de Valenciennes," p. 40 (*Études Gîtes Min. France*).
1891. *Ptychocarpus* Kidston, "Fructification, etc., of Carboniferous Ferns," *Trans. Geol. Soc. Glasgow*, vol. ix, p. 22.
1896. *Ptychocarpus* Renault, "Bassin houil. et perm. d'Autun et d'Épinac," fasc. 4, "Flore Fossile," pt. 2, *Études Gîtes Min. France*, p. 9.
1899. *Ptychocarpus* Potonié, "Lehrb. d. Pflanzenpal.," p. 96.
1900. *Ptychocarpus* Zeiller, "Éléments de paléobotanique," p. 60.
1910. *Ptychocarpus* Seward, "Fossil Plants," vol. ii, p. 397.
1920. *Ptychocarpus* Scott, "Studies in Fossil Botany," 3rd ed., vol. i, p. 252.
1921. *Ptychocarpus* Gothan in Potonié, "Lehrb. d. Pflanzenpal." (Zweite Auflage), p. 64.
1869. *Stichopteris* Weiss (*non* Geinitz), *loc. cit.*, p. 96.
1879. *Stichopteris* Schimper (*non* Geinitz) in Zittel, "Handbuch d. Palaeontologie," Abth. 2, Palaeophytologie, p. 90.

Description.—Fertile and sterile pinnules of similar form. Synangia exannulate, having the external form of a truncate cone composed of five to eight sporangia. Sporangia slightly narrowing towards their apex, outer surface convex, sides flat, and united to each other laterally throughout their whole length and by their inner surface to a central column into which a vascular strand extends to near its summit. The synangia usually form a single row on each side of the midrib of the pinnule, more rarely two rows on each side. Mode of dehiscence unknown.

Remarks.—We are indebted to Renault (*loc. cit.*) for a detailed account of the structure of the synangium of *Ptychocarpus*.

Each loculus or sporangium is surrounded by a wall of delicate tissue and embedded in a lax parenchyma, the whole being enclosed in a common envelope. The means or contrivance by which the spores escaped from the synangia has not been observed.

Dr Scott has suggested (*loc. cit.*, p. 252) that the structure described as the wall of the sporangium may be a tapetum; and such is probably its true nature. As the views he expresses * regarding the affinities of *Ptychocarpus* are those almost uni-

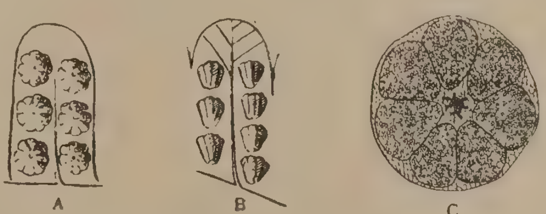
* *Loc. cit.*, pp. 253–254.

versally held, I quote them here. "In general characters, the *Ptychocarpus* fructification approaches most nearly to that of the recent genus *Kaulfussia*, in which the synangia are also circular, but there are many differences in detail. In *Kaulfussia* the interior of the synangium is hollowed out into a cup, into which the sporangia open, dehiscence taking place on the inner face of each sporangium. In the fossil genus there is no central depression, and, as the entire synangium was embedded in a continuous enveloping tissue, dehiscence could only have taken place at the apex. The fructification of *Ptychocarpus unitus* is, however, a good example of a typical Marattiaceous synangium, and affords strong evidence as to the affinities of the plant."

The superficial resemblance to the synangia of *Kaulfussia* is certainly striking, but still the synangia of *Ptychocarpus unitus* Brongniart sp. differ in some very important points from those of *Kaulfussia*, a fact that is well recognized. So far as our present knowledge extends, it appears equally possible that such a synangium might have belonged either to a Marattiaceous fern or to a Pteridosperm. There is not sufficient evidence to confirm the belief that the former plants existed in Carboniferous times. On the other hand, the type of synangium in *Ptychocarpus* corresponds in different degrees with the radial synangia or sporangial groups of *Acitheca*, *Scolecopteris*, etc., which probably, at least possibly, were Pteridosperms (see *ante*, p. 538); and also with the sporangial groups of *Telangium*, which was certainly a Pteridosperm. If the sporangia of *Telangium* became united one would have a synangium comparable to that of *Ptychocarpus*, and if the column in *Acitheca* were extended to the summit of the sporangia a comparable structure would result.

While the question of the affinities of *Ptychocarpus* must be left open, the evidence seems to point as strongly for a reference of the genus to the Pteridosperms as to the Marattiaceæ.

As the few fertile specimens of *Ptychocarpus unitus* found in Britain do not exhibit clearly the form of the synangia, it is shown at text-fig. 70, where A gives a surface-view of the synangia. These seem to have been easily displaced and frequently tumbled over on their side, as seen at B. The grooves passing up their surface mark off the individual sporangia of which the synangium is composed. At C a transverse section of a petrified synangium is given. It shows seven sporangia united laterally to each other and embedded in a delicate cellular tissue, the central column with its vascular strand, to which the sporangia are also united, and the outer layer, which envelops the whole structure.



TEXT-FIG. 70.—*Ptychocarpus unitus* Brongniart sp. A and B, fertile pinnules. C, transverse section of a synangium enlarged thirty times. (A and B after GRAND'EURY; C after RENAULT. Copied from ZEILLER.)

Distribution.—*Ptychocarpus unitus* Brongniart sp. is frequent in the Radstockian Series. It occurs also in the Newcastle-under-Lyme Group of the Staffordian Series, but is rare at that horizon.

Ptychocarpus unitus Brongniart sp.

Plate CXXXI, figs. 1–9, 9*a*; text-figs. 70 and 71.

1833. *Pecopteris longifolia* Brongniart (*non* Phillips), "Hist. des végét. foss.," vol. i, p. 273, pl. lxxxiii, fig. 2.
1838. *Pecopteris longifolia* Sternberg (*non* Phillips), "Versuch," vol. ii, fasc. vii, viii, p. 158.
1845. *Pecopteris longifolia* Germar (*non* Phillips), "Verstein. Steinkohl. von Wettin u. Löbejün," p. 35, pl. xiii, figs. 1–5.
1836. *Diplazites longifolius* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 275.
1883. *Diplazites longifolius* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxvii, Abth. 1, p. 143.
1849. *Desmophlebis longifolia* Brongniart, "Tableau des genres de végét. foss.," p. 23 (*Dict. Univers. d'Hist. nat.*, vol. xiii).
1869. *Goniopteris* (*Desmophlebis*) *longifolia* Schimper, "Traité de paléont. végét.," vol. i, p. 544.
1869. *Stichopteris longifolia* Weiss, "Foss. Flora d. jüngst. Stk. u. Rothl.," p. 97, pls. ix, x, figs. 7, 8.
1870. *Alethopteris longifolia* Lesquereux, "Rept. Geol. Survey of Illinois," vol. iv, p. 469.
1836. *Pecopteris unita* Brongniart, "Hist. des végét. foss.," vol. i, p. 342, pl. cxvi, figs. 1–5.
1838. *Pecopteris unita* Sternberg, "Versuch," ii, fasc. vii–viii, p. 158.
1877. *Pecopteris unita*, Grand'Eury, "Flore carbon. du Dépt. de la Loire," *Mém. Acad. Sci. Paris*, vol. xxiv, no. 1, p. 76, pl. viii, fig. 13.
1879. *Pecopteris unita* Lesquereux, "Coal Flora," vol. i, p. 223, pl. xl, figs. 1–7.
1883. *Pecopteris unita* Renault, "Cours de botan. foss.," p. 119, pl. xx, figs. 11–19.
1884. *Pecopteris unita* Lesquereux, "Indiana, Rept. of State Geologist," pt. 2, Paleont., p. 63, pl. xiii, figs. 3, 3*a*, 3*b*.
1888. *Pecopteris unita* Kidston, "Fossil Flora Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 367, pl. xxiv, figs. 2–9.
1893. *Pecopteris unita* Potonié, "Flora d. Rothl. von Thüringen," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft 9, Theil 2, p. 50, pl. vi, fig. 8*a*′.
1899. *Pecopteris unita* Hofmann and Ryba, "Leitpflanzen," p. 52, pl. vi, figs. 12*a*, *b*.
1899. *Pecopteris unita* Frech, "Lethaea geogn., Theil 1—Lethaea palaeoz.," Band ii, Lief. 2, pl. L^b, figs. 10^a, 10^b.
1888. *Ptychocarpus unitus* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 40, fig. 26.
1888. *Pecopteris* (*Ptychocarpus*) *unita* Zeiller, "Flore foss. terr. houil. de Commentry," *Bull. Soc. Ind. Min.*, ser. 3, vol. 2, livr. 2, p. 162, pl. xviii, figs. 1–5.
1890. *Pecopteris* (*Ptychocarpus*) *unita* Zeiller, "Bassin houil. et perm. d'Autun et d'Épinac," fasc. 2, "Flore Fossile," *Études Gîtes Min. France*, p. 63, pl. viii, fig. 11, text-fig. 31, p. 65.
1891. *Ptychocarpus unitus* Kidston, "On the Fructification, etc., of Carboniferous Ferns," *Trans. Geol. Soc. Glasgow*, vol. ix, p. 22, pl. ii, fig. 22.
1892. *Pecopteris* (*Ptychocarpus*) *unita* Zeiller, "Bassin houil. et perm. de Brive," fasc. 2, "Flore Fossile," *Études Gîtes Min. France*, p. 24.
1899. *Pecopteris* (*Ptychocarpus*) *unita* Zeiller, "Flore foss. bassin houil. d'Héraclée," *Mém. Soc. géol. France, Paléont.*, xxi, p. 33, pl. iii, fig. 8.
1899. *Ptychocarpus unitus* Potonié, "Lehrb. d. Pflanzenpal.," pp. 97, 98, figs. 77, 78.
1900. *Ptychocarpus unitus* Zeiller, "Éléments de paléobot.," p. 60, fig. 28.
1921. *Ptychocarpus* (*Pecopteris*) *unitus* Gothan in POTONIÉ "Lehrb. d. Paläobot." (Zweite Auflage), p. 64, fig. 52.
1848. *Cyatheites unitus* Göppert in BRONN, "Index palaeont.," vol. i, p. 365.
1855. *Cyatheites unitus* Geinitz, "Verstein. d. Steinkf. in Sachsen," p. 25, pl. xxix, figs. 4, 5.
1869. *Cyathocarpus unitus* Weiss, "Foss. Flora d. jüngst. Stk. u. Rothl.," p. 88, pl. xii, figs. 5, 6.
1877. *Oligocarpia unita* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, pp. 294 and 306.

1879. *Stichopteris unita* Schimper in ZITTEL, "Handb. d. Palaeont.," Abth. 2, Palaeophytologie, p. 90, fig. 65 (6–8).
1883. *Diplazites unitus* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," p. 143, *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1.
1885. *Diplazites unitus* Stur, "Carbon-Flora d. Schatzlarer Schichten," p. 214, *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1.
1901. *Diplazites unitus* De Stefani, "Flore Carb. e Perm. della Toscana," p. 32, pl. iii, figs. 1–6 ; pl. vi, fig. 10 (*R. Ist. di Studi sup. pratici e di perfez. in Firenze*).
1890. *Goniopteris* (*Pecopteris*) *unita* Grand'Eury, "Geol. et paléont. du bassin houil. du Gard," p. 278, pl. v, fig. 1.
1836. *Diplazites emarginatus* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 274, pl. xvi, figs. 1, 2.
1883. *Diplazites emarginatus* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," p. 143, fig. 28, p. 140 (*loc. cit.*).
1838. *Pecopteris emarginata* Presl in STERNBERG, "Versuch," ii, fasc. vii-viii, p. 158.
1846. *Pecopteris emarginata* Bunbury, "Fossil Ferns from Frostburg, Maryland," *Quart. Journ. Geol. Soc.*, vol. ii, pp. 84, 90, pl. vi, figs. 1–5.
1879. *Pecopteris emarginata* Lesquereux, "Coal Flora," vol. i, p. 225, pl. xxxix, fig. 11.
1883. *Pecopteris emarginata* Renault, "Cours de botan. foss.," vol. iii, p. 119.
1869. *Goniopteris* (*Desmophlebis*) *emarginata* Schimper, "Traité de paléont. végét.," vol. i, p. 544.
1882. *Goniopteris emarginata* Weiss, "Aus der Flora der Steinkohlenformation," p. 18, pl. 18, fig. 110 (Zweiter Abdr.), (*K. preuss. geol. Landesanst.*).
1899. *Pecopteris* (*Goniopteris*) *emarginata* Hofmann and Ryba, "Leitpflanzen," p. 54, pl. viii, fig. 13.
1870. *Alethopteris emarginata* Lesquereux, "Rept. Geol. Survey of Illinois," vol. iv, p. 398, pl. xiii, fig. 4.
1877. *Oligocarpia emarginata* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Landesanst.*, Band viii, p. 294.
1866. *Pecopteris Lartetii* Bureau, "Plantes fossiles du dépôt houil. de la Rhune (Basses-Pyrénées)," *Bull. Soc. géol. France*, ser. 2, vol. xxiii, p. 847, pl. xiv, figs. 1, 2.
1869. *Ptychocarpus hexastichus* Weiss, "Foss. Flora d. jüngst. Stk. u. Rothl.," p. 95, pl. xi, fig. 2.
1870. *Alethopteris lanceolata* Lesquereux, "Rept. Geol. Survey of Illinois," vol. iv, p. 398, pl. xiii, figs. 1–3.
1879. *Pecopteris lanceolata* Lesquereux, "Coal Flora," vol. i, p. 227, pl. xxxix, figs. 9, 10.
1880. *Goniopteris oblonga*, Fontaine and White, "Perm. or Up. Carb. Flora," p. 83, pl. xxx, figs. 3–5 (*Pennsylvania—Second Geol. Survey, Reports of Progress*, P2).
1880. *Goniopteris elliptica* Fontaine and White, *ibid.*, p. 83, pl. xxx, fig. 1.

Description.—Frond very large, tripinnate, contracted suddenly at apex into an obtuse point. Primary rachis 3 cm. or more in breadth, and bearing small narrow-lanceolate, adpressed, caducous scales, or naked and marked with scattered small elongated cicatricules, which are often scarcely visible. Primary pinnæ alternate, linear-lanceolate, overlapping each other laterally, slightly contracted at base, tapering at apex and terminating in an obtuse point. They attain a length of at least 60 cm. and a breadth of 12 cm. Secondary pinnæ linear, alternate, touching each other laterally or slightly overlapping and contracted at apex into a blunt point; attaining a length of 12 cm. with a breadth of 15 mm. Both primary and secondary pinnæ are very caducous.

Pinnules alternate, margins parallel with rounded apex, attaining a length of 8 mm., contiguous, slightly decurrent and more or less united to each other according to the position on the frond of the pinnæ that bear them. Those on the secondary pinnæ in the middle and lower region of the frond united to each other only from one-sixth to one-quarter of their length; those on the pinnæ towards the summit of the frond or on the apical region of the primary pinnæ become more and more completely united to each other till the secondary pinnæ have only a crenulate margin or may even become entire through the complete union of the pinnules.

Nervation generally distinct. Midrib decurrent, extending to the apex, where it frequently divides into two arms, lateral veinlets opposite, simple, arcuate. As the pinnules become more and more united, the lateral veinlets become more arcuate. Even when the pinnules become united throughout their whole length, the veinlets never extend into the adjoining pinnules.

Fertile pinnæ and pinnules similar to the sterile ones. The fertile pinnules are usually confined to the lower portion of the pinnæ, the upper ones remaining sterile. Sporangia almost cylindrical, contracting slightly upwards with a truncate apex, attached throughout their entire length to a central column and united to each other laterally, the synangium thus formed being enclosed in a common envelope. Each synangium contains from five to eight sporangia. The synangia form a single row on each side of the median vein. Where the pinnules are united to each other for the greater part of their length, the synangia appear as placed in several rows, parallel with and on both sides of the rachis of the pinna. Mode of dehiscence of synangia unknown.

Remarks.—Though by no means a rare species in the Radstock Series, *Ptychocarpus unitus* Brongniart sp. nearly always occurs in a very fragmentary condition. This may be partly accounted for by the tendency of the pinnæ to separate from their parent rachises.

Zeiller, however, has been fortunate in securing some fine examples of *Ptychocarpus unitus*, and from his investigations I have gained a knowledge of the form of the frond.

A part of one of his figures * is given at text-fig. 71. It shows the apex of a frond which must have had a somewhat rounded contour with a small central apical point. This peculiar form of the apex of the frond is brought about by a sudden shortening of the upper primary pinnæ to an almost common level.

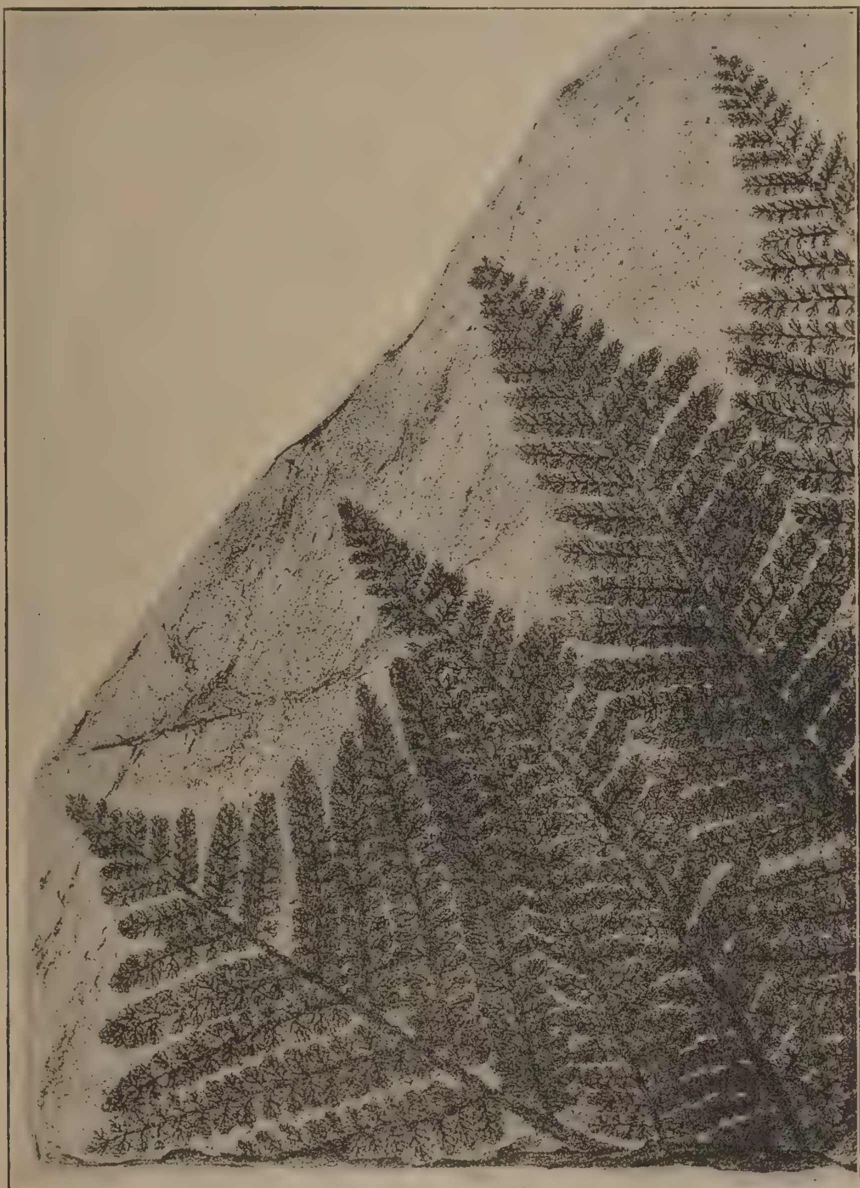
This example also shows the position on the frond of the forms named *Pecopteris longifolia* Brongniart (*non* Phillips) and *Diplazites emarginatus* Göppert.

On our Pl. CXXXI several small specimens of *Ptychocarpus unitus* are given to illustrate the various forms assumed by the pinnules of this polymorphic species.

Fig. 6, Pl. CXXXI, shows, natural size, some reduced secondary pinnæ from near the extreme apex of the frond or perhaps of a primary pinna. The pinnules are here united to each other throughout their whole length, and the pinnæ have an entire margin. The pinnules can, however, be individually distinguished by their nervation, which form separate veinlet systems. A more complete fragment of a primary

* "Flore foss. terr. houil. de Commentry," pl. xviii, fig. 1.

pinna from the apical region of the frond is given at fig. 1, where the pinnules are not united to each other to the same extent as at fig. 6. It represents the terminal part of a primary pinna probably from near the apex of the frond. On this figure



TEXT-FIG. 71.—*Ptychocarpus unitus* Brongniart sp. Termination of a frond, showing the sudden shortening of the upper primary pinnæ. (Part of figure given by ZEILLER in the "Flore foss. terr. houil. de Commentry," pl. xviii, fig. 1.) Natural size.

one can trace the increasing union of the pinnules on the secondary pinnæ as they are followed from below upwards. A small fragment of a similar form is given at fig. 9, natural size, of which two of the component pinnules are enlarged two times at fig. 9*a* to show the nervation. The median vein extends to the top and frequently ends in a small fork. The lateral veins are always undivided and pursue an arcuate course to the margin of the pinnæ. Fig. 8 shows another small fragment, natural size, which in its general form corresponds to the secondary pinnæ seen at the base of fig. 1. The apices of the pinnules are here free, and the lateral veinlets terminate at the margin of the pinnule, not at the margin of the pinna as at fig. 9. Fig. 9 and the upper part of fig. 1 illustrate the form of the species named *Pecopteris longifolia* by Brongniart (*non* Phillips), and that described as *Diplazites emarginatus* by Göppert. Fig. 6, of which two component pinnules are enlarged two times at fig. 6*a*, shows the form named *Pecopteris lanceolata* by Lesquereux, where the pinnules are entirely united and the pinnæ have a smooth margin.

A small specimen corresponding to Brongniart's fig. 1, pl. cxvi, is given at fig. 2. This is probably a fragment of a primary pinna from the middle or lower region of the frond. The pinnules are united to each other at their base for about a quarter of their length, and the nervation is much less arcuate, as seen at fig. 2*a*, which is enlarged two times. As the pinnules become more and more free, the lateral veinlets appear invariably to become less arcuate.

At fig. 3, the terminal portion of a primary pinna is seen. This is probably from a low position on the frond, as the primary pinnæ near the apex seem to contract more or less suddenly into a point, while the lower-situated primary pinnæ appear to have tapered gradually towards the apex.

Figs. 4 and 5 represent other conditions of the plant, where the pinnules are longer in proportion to their length, but otherwise possess the same general characters as those already described. These correspond with Brongniart's fig. 5.

Goniopteris elliptica Fontaine and White and *Goniopteris oblonga* of the same Authors do not differ in any way from *Ptychocarpus unitus*. The former is similar to our figs. 4 and 5, and the latter to fig. 2.

None of our specimens shows the fructification in a good state of preservation, but a small portion of a fertile secondary pinna is given at fig. 7, natural size. Each component pinnule had a single row of synangia situated midway between the median vein and the margin of the pinnule, and cover the whole of its under surface. This gives an appearance to the pinna, as if the synangia were arranged in several rows parallel with the rachis. The synangia seem to have been borne only on the pinnules situated on the lower portion of the secondary pinnæ.

Pecopteris Larteti Bureau has been founded on a small fragment of *Ptychocarpus unitus*, and must be united with that species. It is similar to our fig. 8. As pointed out by Grand'Eury,* *Ptychocarpus hexastichus* Weiss only represents a fertile specimen of *Pecopteris unita* Brongniart, on which the synangia have been bent over and deformed by pressure.

Zeiller has suggested that perhaps the *longifolia* form of *Ptychocarpus unitus* may have extended over a greater part of the frond in Permian than in Carboniferous times, since he found it to be the prevailing form of the species in the Permian of Brive. †

* "Flore carb. du Dépt. de la Loire," p. 76.

† Zeiller, "Bassin houil. et perm. de Brive," p. 24.

Ptychocarpus unitus Brongniart sp. is easily distinguished by the pinnules being more or less united to each other, by the lateral veinlets being always undivided and more or less distinctly arcuate.

Distribution.—Ptychocarpus unitus is frequent in the Radstock Group and Farrington Group of the Radstockian Series, but appears to become rare in the Keele Group. It occurs also in the Newcastle-under-Lyme Group of Staffordian Series, but is very rare at that horizon.

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon: ?. *Localities:* Radstock, Somerset; Wellsway Pit, Radstock; Braysdown Colliery, near Radstock; Kilmersdon Pit, near Radstock; Upper Conygre Pit, Timsbury, $2\frac{1}{2}$ miles north of Radstock; Lower Conygre Pit, Timsbury; Camerton, 2 miles north of Radstock; Norton Hill Pit, Midsomer Norton, $1\frac{1}{2}$ mile west of Radstock.

Somerset and Bristol Coalfield.

FARRINGTON GROUP.

Horizon: ?. *Localities:* Old Mills Pit, Farrington Gurney, Somerset; Farrington Pit, Farrington Gurney.

South Wales Coalfield.

FARRINGTON GROUP.

Horizon: Aft Seam (= Four-foot seam). *Locality:* Old levels at Melin Llan, $\frac{1}{2}$ mile north-east of Penller-gaer Church, Glamorganshire (Collection of Geological Survey, London).

Horizon: Graigola Seam. *Localities:* Clydach Merthyr Colliery, 500 yards W.S.W. of Pen-y-banc Farm, Glamorganshire (Collection of Geological Survey, London); Moortown Colliery, about 2 miles west of Neath Station, Glamorganshire (Collection of Geological Survey, London).

Horizon: Four-foot Seam of Swansea. *Locality:* Gladys Colliery, 1 mile E.S.E. of Penller-gaer Church, Glamorganshire (Collection of Geological Survey, London).

Horizon: No. 2 Llantwit Seam. *Locality:* Graiglas, near Gilfach Goch, Glamorganshire (D. Davies).

Horizon: Mynyddlwyn Seam. *Localities:* Gelli-deg Level, Maes-y-Cwmmer, Monmouthshire (Collection of Geological Survey, London); Gwernau Level, $\frac{1}{3}$ mile east of the Boot, Monmouthshire (Collection of Geological Survey, London).

Horizon: Wernffraith Seam. *Locality:* Bevan's Drift, about 1 mile north of Neath Station, Glamorganshire (Collection of Geological Survey, London).

Horizon : ?. *Locality :* Old Quarry at Melin Crythan, about 100 yards below Eaglesbrook Foundry, near Neath Station, Glamorganshire (Collection of Geological Survey, London).

South Staffordshire Coalfield.

KEELE GROUP.

Horizon : ?. *Locality :* Hamstead Colliery, Great Barr, 2½ miles south-east of Walsall.

North Wales Coalfield.

? KEELE GROUP.

Horizon : ?. *Locality :* Old tip, 170 yards north of Flannog Farm, north of Chirk, Denbighshire (Collection of Geological Survey, London).

STAFFORDIAN SERIES.

Forest of Wyre Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon : At depth of 1447–1449 feet. *Locality :* Claverley Boring, 5 miles east of Bridgnorth, Shropshire (Collection of Geological Survey, London).

Somerset and Bristol Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon : ?. *Locality :* Bromley Colliery, 1 mile west of Pensford, Somerset (R. Crookall).

Genus **Eupecopteris** Kidston (Gothan Group, *pars*).

1921. Group *Eu-Pecopteris* Gothan (*pars*) in Potonié, "Lehrb. d. Paläobot." (Zweite Auflage), p. 92.

Description.—Form-genus. Fronds usually of a large size, bipinnate or tripinnate. Pinnules alternate, more or less oblong or tongue-shaped, attached by the whole width of their base to the rachis or slightly contracted, but not pedicellate, sometimes decurrent, free or united to each other. Median vein straight or slightly decurrent, lateral veinlets simple or several-times dichotomously divided. Fructification unknown.

Remarks.—This genus is employed for the reception of those species known only in the sterile condition, but whose pinnules are similar in form and nervation to those of *Asterotheca*, *Ptychocarpus*, and *Acitheca* ; it is probable that some of them at least, if discovered in the fertile condition, would find a place in one or other of these three genera.

The genus *Eupecopteris* differs from *Pecopteris* in the tongue-shaped form of the pinnules, and in their nervation, which consists of a median vein that generally gives off dichotomously-divided, straight, or arcuate veinlets. In *Pecopteris*, on the other hand, as employed here, are included all those species (not otherwise included in other genera founded on their fructification) whose pinnules are attached to the rachis by a broad base, but have not the form of those of *Eupecopteris*, and whose nervation may be sphenopteroid or have any other arrangement.

The plants included in *Eupecopteris* form a distinct group from those included here in *Pecopteris*, and for the purpose of recording their occurrence it is of considerable advantage, when the specific name is not known, to be able to distinguish to which of these groups the record refers.

Distribution.—The majority of the *Eupecopteris* species occur in the higher horizons of the Coal Measures, but in Britain one is known from the Lanarkian Series, two from the Westphalian Series, a few more occur at the top of the Staffordian Series; but their principal occurrence is in the Radstockian Series.

Eupecopteris Bucklandi Brongniart sp.

Plate CXX, figs. 6, 6*a*; Plate CXXXII, figs. 1, 1*a*, 1*b*, 2; text-figs. 72 and 73.

1828. *Pecopteris Bucklandii* Brongniart, "Prodrome," p. 56.
1834. *Pecopteris Bucklandii* Brongniart, "Hist. des végét. foss.," vol. i, p. 319, pl. xcix, fig. 2.
1838. *Pecopteris Bucklandi* Presl in Sternberg, "Versuch," fasc. vii–viii, p. 156.
1893. Cf. *Pecopteris Bucklandi* Potonié, "Flora d. Rothl. von Thüringen," p. 96, pl. xxiii, fig. 3. (*Excl. ref.*)
1907. *Pecopteris Bucklandi* Sterzel, "Karbon-u. Rothlfl. im Grossherzogtum Badens," *Mitteil. badischen geol. Landesanst.*, Band v, Heft 2, p. 422, pl. xvii, figs. 2, 2*a*; p. 494, pl. xxvi, figs. 3 at A, 3*a*.
1919. *Pecopteris Bucklandi* Kidston, "List of Fossil Plants from Coal Measures of Borings at . . . Folkestone, . . . Kent," *Mem. Geol. Survey, Summary of Progress for* 1918, p. 47.
1836. *Alethopteris Bucklandii* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 314.
1845. *Alethopteris Bucklandii* Unger, "Syn. plant. foss.," p. 84.
1848. *Alethopteris Bucklandi* Bronn, "Index palaeont.," p. 23.
1850. *Alethopteris Bucklandii* Unger, "Genera et species," p. 152.
1879. *Acitheca Bucklandi* Schimper in Zittel, "Handb. d. Palaeont.," Abth. 2, Palaeophytologie, p. 91.

Description.—Frond large, tripinnate. Primary pinnæ linear-lanceolate, gradually narrowing at the apex and terminating in a sharp point, rachis faintly striated longitudinally and bearing small scattered apiculi. Secondary pinnæ alternate, linear-lanceolate, contracting from about their centre and ending in a more or less sharp point with an obtuse terminal lobe, usually free and only rarely touching laterally, attaining a length of 9 cm. and a breadth of 1·5 cm. or more. As traced towards the apex of the primary pinnæ, the secondary pinnæ become gradually shorter and the pinnules more and more united to each other, with an accompanying increase in the size of the terminal lobe till finally the pinnæ assume the form of pinnules.

Pinnules alternate, almost upright, or more or less oblique to rachis. On the lower-placed secondary pinnæ the pinnules are one and a half to three times longer than broad, oblong, sides almost parallel or very gradually narrowing upwards and terminating in an obtuse point, free and contracted at base or decurrent on posterior margin, with an ingoing sinus on anterior margin, very rarely slightly united to each other at base. On the secondary pinnæ, near the apex of the primary pinnæ, the pinnules become gradually more and more united to each other and eventually form a crenate margin to the pinnæ. By a further union of the pinnules the crenatures disappear, and finally the pinnæ assume the form of elongated pinnules. The pinnules on the anterior side of the pinnæ are frequently shorter and stand more upright to the rachis than those on the posterior side.

Nervation most distinctly seen on the dorsal surface of the pinnules. Median vein thick, straight, or very slightly decurrent in the pinnules, which are united to each other at the base, extending to the summit of the pinnule. The somewhat distant lateral veinlets depart at an acute angle, divide into two arms at their extreme base, and pursue an upward course to the margin of the pinnule. In the lower portion of the pinnule, the upper arm of the fork frequently again divides.

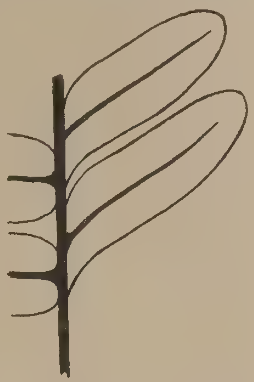
Fructification unknown.

Remarks.—On Pl. CXXXII, fig. 1, part of two primary pinnæ is given natural size. Neither is complete at its lower end, but the larger is 29·5 cm. in length, and the other and more perfect is 10 cm. in breadth. To judge from their positions, they both evidently originated from the same rachis. For some distance below the apex the secondary pinnæ gradually become shorter and the primary pinnæ terminate in a sharp point. The secondary pinnæ are alternate, free, closely placed to each other, but do not touch laterally. Those holding lower positions on the primary pinnæ are of about constant width for half their length, then taper gradually to a point and terminate in an obtuse lobe; the upper secondary pinnæ have more obtuse points.

The pinnules are oblong, with almost parallel sides, but narrow slightly upwards and end in a bluntly rounded apex. The pinnules on the anterior side of the rachis stand more upright to the rachis than those on the posterior side. This, though not a constant character, is very frequent, but is scarcely observable on Brongniart's figure of the species. The pinnules on the anterior side are usually contracted at the base, and those on the posterior side may also have the same form. Frequently, however, they are rounded on their anterior margin by an ingoing sinus and free, but may be very slightly united to each other, as seen at fig. 1*a* (enlarged three times). On the secondary pinnæ, near the apex, the pinnules become more and more united to each other, and the terminal lobe gradually increases in size as the pinnæ become shorter, till at the apex the secondary pinnæ are reduced to the form of pinnules. These features are well seen on the more perfect primary pinnæ given on Pl. CXXXII.

The median vein is thick and the somewhat distant lateral veins depart at an acute angle. They divide into two arms at their extreme base and follow an ascending course to the margin of the pinnule. On this specimen the veins seem to be only once divided, as seen at fig. 1*a*, and in the pinnule enlarged about seven times at fig. 1*b*, Pl. CXXXII.

Part of another primary pinna is given natural size on Pl. CXX, fig. 6. The pinnules here are slightly more distant than on the specimen just described, and those on the anterior side of the rachis are also a little smaller and stand more upright to the rachis than those on the posterior side. The pinnules are all free except at the extreme apex of the pinnæ. Those on the anterior side of the rachis, especially on the lower-situated pinnæ, have contracted or rounded bases, while those on the posterior side have also frequently rounded bases, though a few are decurrent on their posterior margin with an ingoing sinus at the base on their anterior margin. They do not unite with each other, however. This condition is seen at text-fig. 72, where the posterior pinnules are decurrent and the anterior ones rounded at base. Sometimes in these decurrent pinnules the median vein is straight, as in the pinnules with contracted base, but more often is very slightly decurrent.



TEXT-FIG. 72.—*Eupecopteris Bucklandi* Brongniart sp. Pinnules enlarged about four times to show some with contracted base on anterior side of rachis and with decurrent base on posterior side.

Another pinnule from the same specimen is enlarged seven times at text-fig. 73 to show the contracted base and nervation. Here the upper arm of the lateral veinlets in the lower part of the pinnule again divides.

A small fragment of a secondary pinna, enlarged two times, is given at fig. 2, Pl. CXXXII. This is very similar to the specimen figured by BRONGNIART in the form and slight decurrence of the pinnules. The nervation is also similar, the lower lateral veinlets ending in three arms. The pinnules are here also very slightly united to each other at the base, as seen in his enlarged fig. 2*a*.

TEXT-FIG. 73.—*Eupecopteris Bucklandi* Brongniart sp. Pinnule enlarged seven times to show contracted base and nervation.

Pecopteris pseudo-Bucklandi Andrae * has been united by WEISS † and POTONIÉ ‡ with *Eupecopteris Bucklandi,* and at one time I adopted the same course,§ but in this I am now convinced I was wrong.

Pecopteris pseudo-Bucklandi Andrae differs from *Eupecopteris Bucklandi* in the pinnules being attached by their whole base, which is neither contracted nor decurrent; they stand very close to each other and are free or only very slightly united; the first dichotomy of the lateral veinlets takes place some distance above their base, and each arm usually again divides in its course to the margin of the pinnule, where they are more numerous and closer than in *Eupecopteris Bucklandi.* In the latter species the

* ANDRAE in GERMAR, "Verstein. Steinkohl. v. Wettin u. Löbejün," p. 106, pl. xxxvii, 1853.

† "Foss. Flora d. jüngst. Stk. u. Rothl.," p. 64, 1869.

‡ "Flora d. Rothl. von Thüringen," p. 96, 1893.

§ "Catal. Palæozoic Plants in British Museum," p. 117, 1886.

pinnules are very distinctly contracted at base, more rarely decurrent and united. The lateral veinlets divide at their extreme base, and in the lower part of the pinnules the upper arm of the fork may dichotomize, but it often remains simple. The nervation is also more distant. These differences at once distinguish the two species.

The species for which *Eupecopteris Bucklandi* is most likely to be mistaken is *Asterotheca oreopteridia* Schlotheim sp., but in that species the pinnules are not contracted at the base, but are attached to the rachis by their whole width and are shorter in proportion to their breadth. The nervation also differs in that the first division of the lateral veinlets takes place a short distance above their base, their course to the margin is less ascending, and they are usually only once divided.

The more-divided lateral veinlets and their less-ascending course to the margin easily distinguish *Eupecopteris Cisti* from *Eupecopteris Bucklandi*.

The plant identified as *Pecopteris Bucklandi* by Lindley and Hutton * is *Neuropteris rarinervis* Bunbury. The original specimen is preserved in the Hutton Collection, Hancock Museum, Newcastle-on-Tyne. The character of the matrix in which the specimen is preserved makes it most improbable that their specimen was derived from the "Newcastle coal-field," as stated by them.

Schimper † includes *Eupecopteris Bucklandi* in his genus *Acitheca*, but I do not know of any published description of the fructification of this species.

Distribution.—*Eupecopteris Bucklandi* Brongniart sp. is rare and has been found only in the Radstockian Series and the uppermost group of the Staffordian Series. Of the few specimens known to me from the Radstockian Series (including Brongniart's type), five are from the original locality, Camerton. In the Staffordian Series it is even more rare.

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon: ?. *Locality:* Radstock, Somerset; Camerton, 2 miles north of Radstock.

South Wales Coalfield.

FARRINGTON GROUP.

Horizon: No. 3 Llantwit Seam. *Locality:* Cross Inn, near Llantrisant, Glamorganshire (D. Davies).

STAFFORDIAN SERIES.

Somerset and Bristol Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: ?. Coal Pit Heath, near Bristol, Gloucestershire (R. Crookall).

* "Fossil Flora," vol. iii, pl. ccxxiii.

† *Loc. cit.*

KENT COALFIELD.

? ETRURIA MARL GROUP.

Horizon: At depth of 2950–2955 feet. *Locality:* Boring at Tower Brickworks, Folkestone, Kent (Collection of Geological Survey, London).

Eupecopteris Cisti Brongniart sp.

Plate CXXXV, figs. 1, 1*a*; text-fig. 74.

1834. *Pecopteris Cistii* Brongniart, " Hist. des végét. foss.," vol. i, p. 330, pl. cvi, figs. 1, 2.
1869. *Pecopteris Cistii* Schimper, " Traité de paléont. végét.," vol. i, p. 510.
1879. *Pecopteris Cistii* Lesquereux, " Coal Flora," vol. i, p. 243, pl. xli, fig. 4.
1836. *Alethopteris Cistii* Göppert, " Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 316.
1838. *Alethopteris Cistii* Presl in STERNBERG, " Versuch," ii, fasc. vii-viii, p. 145.
1845. *Alethopteris Cistii* Unger, " Synop. plant. foss.," p. 85.
1848. *Alethopteris Cisti* Bronn, " Index palaeont.," p. 23.

Description.—Frond probably tripinnate. Primary pinnæ . . . rachis straight, rather slender, with very fine longitudinal striations and a few scattered small apiculi. Secondary pinnæ alternate, linear-lanceolate, more or less gradually tapering from a short distance above their base and ending in an obtusely-pointed, small terminal lobe, free or occasionally touching laterally at base, and attaining a length of 7·5 cm. or more, rachis straight. Pinnules alternate, free, with contracted base or slightly decurrent and slightly united to each other, sides straight, with an obtuse, rounded apex. The basal posterior pinnule is placed at the extreme end of the pinna-rachis. Median vein thick, extending to near the summit of the pinnule, where it breaks into four veinlets. Lateral veinlets departing at a more or less acute angle, dividing once or twice in their ascending course to the margin of the pinnule.

Remarks.—*Eupecopteris Cisti* Brongniart sp. is a very rare species, and the only figured specimens are those given by BRONGNIART.* The original of fig. 1 came from Wilkesbarre (Pennsylvania), and that of his fig. 2 from Dunkerton (Somerset), part of which has been copied by LESQUEREUX.†

To this species I refer the specimen given natural size on Pl. CXXXV, fig. 1. It shows what I believe to be part of a primary pinna, though BRONGNIART, who figures a similar portion, thought that his example was part of a bipinnate frond, on account of the lateral pinnæ decreasing in length towards the base of the specimen, but a similar decrease towards the base occurs also in primary pinnæ. The whole appearance of the two specimens he figures agrees so completely with the primary pinnæ of its allies that I can only regard his two specimens as showing fragments of primary pinnæ.

Of the two specimens figured by BRONGNIART, our example agrees better with

* " Hist. des végét. foss.," pl. cvi, figs. 1 and 2.

† " Coal Flora," pl. xvi, fig. 4.

that from Wilkesbarre, on which the secondary pinnæ taper more gradually to a point than on the specimen from Dunkerton. Some pinnæ of the latter taper more gradually upwards than others, which contract more suddenly at the apex. Both specimens, however, appear undoubtedly to belong to the same species.

The pinnules are oblong, with comparatively straight sides and very bluntly rounded apices, united by all their base to the rachis, and may be decurrent and slightly united to each other, or free and distinctly contracted at the base, when they have a neuropteroid appearance. Both these forms of pinnule are distinctly seen on the specimen given here on our Pl. CXXXV, fig. 1, and on the portions of two neighbouring pinnæ, enlarged three times at fig. 1*a*, to show the free pinnules with contracted bases and the decurrent pinnules united to the rachis by the whole width of their base. A pinnule from this specimen is enlarged six times at text-fig. 74, which shows the nervation and the slight union of the pinnules to each other. The median vein is thick and straight, and at its upper end usually terminates in four veinlets. The lower lateral veinlets generally dichotomize twice, the first dichotomy taking place close to their base, the upper veinlets may have two, three, or four ultimate divisions. The lateral veinlets in the pinnules of our specimen vary somewhat in the steepness of their ascending course to the margin. If one examines the nervation of the pinnules enlarged at fig. 1*a*, one will observe that the lateral veinlets of the broader pinnules at A (and text-fig. 74) take a more direct course to the margin than those in the more narrow pinnules seen at B, which in this respect more resemble those of BRONGNIART's enlargements.

TEXT-FIG. 74. — *Eupecopteris Cisti* Brongniart sp. Pinnule enlarged six times to show the nervation.

GÖPPERT (*loc. cit.*) placed *Eupecopteris Cisti* in the genus *Alethopteris*, and has been followed in this by several botanists. Probably GÖPPERT was influenced in according this position to the plant by the fact that some of the pinnules in the enlarged figures given by BRONGNIART show a few simple veins passing directly from the rachis into their base. BRONGNIART in his description of the nervation makes no mention of these, and had they been present on the specimen it is unlikely that they would have escaped his observation. He thus describes the nervation, "Nervo medio valide notato ; nervulis arcuatis bis furcatis, distantibus tenuissimis." I therefore think that we may ascribe the few simple veins, which are shown to pass from the rachis into the pinnules, to the artist who prepared the figures.

Eupecopteris Cisti has some resemblance to *Acitheca polymorpha* Brongniart sp. in the form of the pinnules and in the basal posterior pinnule being placed at the extreme base of the pinna rachis, but the nervation is more distant and pursues a more ascending course to the margin, especially in the more elongated pinnules. This will be seen if fig. 1*a*, Pl. CXXXV, be compared with the enlarged figures of pinnules of *Acitheca polymorpha* given on Pl. CXXIX, figs. 1*a* and 1*b*, and fig. 4*a*, Pl. CXXX. From *Eupecopteris pteroides* Brongniart sp. *Eupecopteris Cisti* is at once distinguished by its less numerous and much more distant lateral veinlets (*cf.* Pl. CXXX, fig. 1*a*).

Distribution.—*Eupecopteris Cisti* is very rare, and I know of only three British specimens, two from the Radstock Series and one from the uppermost Group of the Staffordian Series.

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon: ?. *Locality:* Braysdown Colliery, near Radstock, Somerset.

FARRINGTON GROUP.

Horizon: ?. *Locality:* Dunkerton, 4½ miles south-west of Bath, Somerset (one of the types figured by Brongniart, "Hist. des végét. foss.," pl. cvi, fig. 2).

STAFFORDIAN SERIES.

Somerset and Bristol Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: ?. *Locality:* Coal Pit Heath, near Bristol, Gloucestershire (Mrs Barclay).

Eupecopteris pteroides Brongniart sp.

Plate CXXX, figs. 1 and 1*a*; text-fig. 75.

1834. *Pecopteris pteroides* Brongniart (*non* Schlotheim), "Hist. des végét. foss.," p. 329, pl. xcix, fig. 1.
1838. *Pecopteris pteroides* Presl in Sternberg, "Versuch," ii, fasc. vii–viii, p. 148.
1853. *Pecopteris pteroides* Andrae in Germar, "Verstein. d. Steinkohlengebirges v. Wettin u. Löbejün," p. 103, pl. xxxvi.
1869. *Pecopteris pteroides* Schimper, "Traité de paléont. végét.," vol. i, p. 508.
1877. *Pecopteris pteroides* Grand'Eury, "Flore carb. du Dépt. de la Loire," *Mém. Acad. Sci. Paris*, xxiv, no. 1, p. 75.
1852. *Alethopteris pteroides* Giebel, "Deutschl. Petrefacten," p. 51.
1869. *Asterocarpus pteroides* Weiss, "Foss. Flora d. jüngst. Stk. u. Rothl.," p. 91.
1876. Cf. *Asterocarpus pteroides* Heer, "Flora foss. Helvetiæ," p. 31, pl. xiii, figs. 1–5 (*non* fig. 5*b*).
1883. *Scolecopteris pteroides* Stur, "Morph. u. Syst. d. Culm-u. Carbonfarne," *Sitz. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 125.
1885. *Scolecopteris pteroides* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 205.
1836. *Alethopteris Brongniartii* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 314.
1848. *Alethopteris Brongniartii* Bronn, "Index palaeont.," p. 23.
1850. *Alethopteris Brongniartii* Unger, "Genera et species," p. 153.

Description.—Frond probably very large, tripinnate. Primary pinnæ lanceolate, margins overlapping. Secondary pinnæ alternate, or sub-opposite, broadly linear-lanceolate, of almost equal width till near the apex, where they contract suddenly into a blunt point, free, or margins slightly overlapping, more or less oblique to rachis, 7 cm. or more in length and about 2 cm. in breadth; rachis straight. Pinnules more or less oblique to rachis; alternate, oblong, two and a half to three and a half times as long as broad, narrowing gradually upwards and terminating in a blunt point, free, and slightly contracted at base. Basal pinnule on posterior side of rachis situated in the angle formed by the union of the pinna with its parent rachis or on the rachis of the primary pinna immediately below the insertion of the secondary pinna.

Nervation: median vein extending to near the apex, where it divides into one or two forks. Lateral veinlets alternate or sub-opposite, departing from the median vein at an acute angle, then curving outwards to the margin and dividing into four to six veinlets, the ultimate branches of which are closely placed to each other at the margin. The first dichotomy occurs near the base, and each arm again dichotomizes; in a few cases a third dichotomy occurs.

Remarks.—The only British specimen of *Eupecopteris pteroides* Brongniart sp. that I have seen is that given natural size at fig. 1, Pl. CXXX, which is preserved in the Geological Department of the British Museum; my thanks are due to Sir Arthur Smith Woodward for permission to figure and describe it. This specimen shows portions of two primary pinnæ, the more complete of which does not exhibit any part of the rachis, but the other fragment seen at *a, a,* shows the thick rachis and the connexion of the basal portion of some of the secondary pinnæ. The secondary pinnæ are broad in proportion to their length, of almost equal width till near their apex, where they contract suddenly and terminate in a rather small lobe. The pinnules are oblong, free, very closely placed, usually touch each other laterally, and are slightly rounded at the base. They contract gradually from the base to the apex, and end in a bluntly rounded point (Pl. CXXX, fig. 1*a*, and text-fig. 75). The basal pinnule on the posterior side of the pinnæ is situated in the angle formed by the union of the pinnæ with their parent rachis. This is seen at the base of the pinnæ lettered *a, a,* and the one above them. Brongniart states that this posterior basal pinnule may be even situated on the rachis of the primary pinna, entirely free from the rachis of the secondary pinna; and he shows one so situated on his enlarged figure, but neither on the specimens figured by Germar nor on our example do any occur so situated, nor is it a constant character on the type-figure of Brongniart.

The median vein is thick, and the lateral veinlets depart from it at an acute angle and pursue an arcuate course to the margin. These divide twice, and one or more of the resulting veinlets may again divide. This repeated dichotomy of the veinlets produced a series of very closely-placed ultimate veinlets at the margin of the pinnule. The nervation is seen in the pinnules enlarged three times at fig. 1*a*, Pl. CXXX, and at text-fig. 75, which is enlarged six times.

The species with which *Eupecopteris pteroides* is most likely to be mistaken is

Acitheca polymorpha Brongniart sp., but from that it is distinguished by its closer nervation, and the lateral veinlets are usually divided to a greater extent and have a more oblique arcuate course to the margin, and especially by the basal posterior pinnule being placed in the angle formed by the union of the secondary pinnæ to the primary rachis. The pinnules also taper gradually from the base upwards, have a more narrow, blunt apex, and do not become united to each other at the base, as is often the case in *Acitheca polymorpha*.

Text-fig. 75.—*Eupecopteris pteroides* Brongniart sp. Pinnule enlarged six times to show the nervation. Specimen in the Geological Department of the British Museum, No. 39050.

The plant named *Alethopteris pteroides*, by Geinitz,* as pointed out by Grand'Eury,† is not the plant described by Brongniart under that name.

Pecopteris pteroides Lesquereux ‡ must also be excluded from Brongniart's species, as the description he gives of his specimens, which are not figured, does not agree with *Pecopteris pteroides*.

It is also doubtful if the specimens assigned by Heer § to Brongniart's species under the name of *Asterocarpus pteroides* belong to it. The reference is therefore omitted from the synonymy given above.

Brongniart erroneously identified his *Pecopteris pteroides* with *Filicites pteridius* Schlotheim,|| which is essentially distinct and is now included in the genus *Callipteridium* Weiss.¶

Distribution.—Very rare. The only example of *Eupecopteris pteroides* Brongniart sp. that I have seen is shown on our plate.

Somerset and Bristol Coalfield.

Horizon and *Locality:* The locality given for this specimen is "near Bath." It almost certainly was derived from the Radstockian Series of Radstock, Somerset (Geological Department, British Museum, No. 39050).

* "Verstein d. Steinkohlf. in Sachsen," p. 28, pl. xxxii, figs. 1–5.

† "Flore Carb. du Dépt. de la Loire," p. 75, 1877.

‡ "Coal Flora," vol. i, p. 249, 1880.

§ "Flora foss. Helv.," p. 31, pl. xiii, figs. 1–4, 1877.

|| "Flora d. Vorwelt," p. 59, pl. xiv, fig. 27, 1804. *Filicites pteridius* Schlotheim, "Petrefactenkunde," p. 406, 1820.

¶ Weiss, "Studien über Odontopteriden," *Zeitschr. deutsch. geol. Gesellsch.*, 1870, p. 858. *See also* Zeiller, "Flore foss. terr. houil. de Commentry," pt. 1, p. 198, 1888, and Potonié, "Flora d. Rothl. v. Thüringen," pp. 67–68, 1898. *Callipteridium pteridium* Schlotheim sp. is the same plant as that subsequently described by Brongniart under the name of *Pecopteris ovata* ("Hist. des végét. foss.," p. 328, pl. cvii, fig. 4).

Eupecopteris Fletti Kidston n. sp.

Plate CXXV, figs. 2, 2*a*; Plate CXXXIII; Plate CXXXIV, figs. 1, 1*a*, 1*b*; text-fig. 76.

Description.—Frond very large, tripinnate-pinnatifid or probably quadripinnate at base. Main rachis punctate. Primary pinnæ more than 42 cm. in length, lanceolate, narrowed at base, broadest part about two-thirds their length from base, overlapping at the margins, rachis straight, 9 mm. in breadth, densely apiculate. Secondary pinnæ at broadest part of primary pinnæ lanceolate, gradually tapering to a sharp point, oblique, 12 cm. in length and nearly 2 cm. in breadth; rachis straight, at base of primary pinnæ the secondary pinnæ are about 6 cm. in length, about 2 cm. in breadth, and of almost equal width till near the apex, where they suddenly contract and terminate in a blunt point. Tertiary pinnæ about 1·50 cm. or more in length and 5 mm. in breadth, very obtuse.

Pinnules with smooth upper surface attached by a broad base, free, close or slightly distant, varying in proportion of length to breadth on the secondary pinnæ of the same region of the frond; those on the posterior side of the pinnæ of the central region, 9 mm. to 11 mm. in length and about 4 mm. in breadth, slightly rounded at base, tapering very gradually upwards and ending in a blunt point; pinnules on anterior side of rachis shorter and broader in proportion to their length, about 8 mm. to 9 mm. in length and about 4 mm. in breadth, with slightly rounded base, gradually tapering upwards and ending in an obtuse apex. On the upper secondary pinnæ the pinnules are slightly smaller, but of a similar form on both sides of the rachis. On the tertiary pinnæ at basal region of frond the pinnules are confluent and only individually distinguishable by a blunt marginal lobe which represents their apex.

Nervation usually distinct, median vein straight, thick, the lateral veinlets go off at a wide angle and dichotomize near their base; the upper fork almost invariably again dichotomizes except in a few of the pinnules at the apex of the pinnæ, and in all the pinnules of the apical secondary pinnæ, where the lateral veins are usually only once divided.

Remarks.—Plate CXXXIII shows portion of a large slab on which the remains of three incomplete primary pinnæ are seen lying parallel to each other. A portion of one of them, 42 cm. in length and 18 cm. in breadth at its widest part, is seen at the bottom of the plate. The rachis is straight and 8 mm. in breadth at the base. It is densely apiculate. The secondary pinnæ spring from it at an angle of about 40°. Those which arise from what I believe to be the anterior side of the primary pinna at its widest part, are 12 cm. in length and 2 cm. in breadth, lanceolate, gradually taper from about their middle and end in a sharp point. Those holding a corresponding position on the posterior side are shorter and broader. They are of almost constant width till within about a quarter of their length from the apex, where they more quickly contract and end in a blunt point. From about the middle of the primary pinna or a little below, the secondary pinnæ become gradually shorter, and at the lower end of our specimen they are about 6·5 cm. in length and about 2 cm. in breadth. The small size of the secondary pinnæ at the fractured lower end of our specimen would seem to indicate that only a small part of the basal region of this primary pinna is missing. A larger portion seems to have been broken off the apex. When perfect, the primary pinna could not have been less than 50 cm. in length.

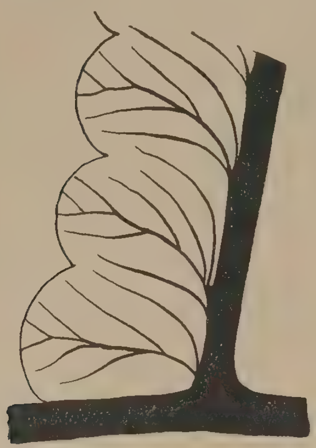
The pinnules borne on the secondary pinnæ arising from the anterior margin are shorter, proportionately broader, and slightly more distant than those on the opposite side of the rachis. The pinnules are free, slightly rounded at base, apparently never decurrent, have almost straight sides with bluntly rounded apices. Some of the pinnules at the base of the pinnæ have a few rounded lobes. This is seen on some of the pinnules at the bottom of our figure, and the lobing of the pinnules becomes more frequent at a lower level than that seen on the plate.

A short distance above what appears to have been the middle of the primary pinna, the secondary pinnæ gradually decrease in length and the pinnules undergo a corresponding diminution in size, but the distinctive form of the pinnules on the pinnæ borne on the two sides of the primary rachis continues.

At the bottom of the slab bearing the pinnæ shown on Pl. CXXXIII is a fragment of a large, densely apiculate rachis, possibly a part of that which bore the figured pinnæ.

Another specimen showing portions of two primary pinnæ is given on Pl. CXXXIV, fig. 1. The characteristic difference in the form of the pinnules on the secondary pinnæ of the two sides of the primary pinnæ is prominently seen. Towards the centre of the figure several of the pinnules on the pinnæ on the anterior side are more or less crenate. These show an early stage in the formation of tertiary pinnæ, and it is most unusual that the pinnules on the secondary pinnæ holding a lower position retain the normal form of pinnules, while those holding a higher level have begun to assume the form of pinnæ. A pinnule of the usual type of those on the secondary pinnæ on the anterior side of the primary pinna is enlarged three times at fig. 1*a* to show the nervation. The lateral veinlets divide near their base, and the upper fork again divides. This seems to be an almost constant feature of the lateral veinlets except in a few of the uppermost pinnules on the secondary pinnæ, and in the pinnules on the secondary pinnæ at the apex of the primary pinnæ, where the lateral veinlets may undergo only a single dichotomy. At fig. 1*b* a portion of a secondary pinna from the same specimen is enlarged three times to show the early transition stage from pinnule to pinna. Here the pinnules are becoming crenate and each of the rounded lobes is supplied with its own system of veinlets, usually four. These structures are potentially tertiary pinnæ, but the point at which a pinnule ends and a pinna begins is sometimes difficult to decide, as the one gradually passes into the other.

The next stage in the transition from pinnule to pinna is shown in the specimen of *Eupecopteris Fletti* given at fig. 2, Pl. CXXV. This is evidently from a lower position on the frond than that from which originated the two specimens described above. At the upper end of this example the tertiary pinnæ, for such they must now be termed, are in the same condition of development as that seen on Pl. CXXXIV, fig. 1*b*, but at the base of the specimen the pinnules become distinctly individualized, each possessing its own system of veins and rounded apex; and unitedly they form the crenulate margin to the pinnæ, which may now be described as a tertiary pinna with confluent pinnules. The three tertiary pinnæ, enlarged three times at Pl. CXXV, fig. 2*a*, show these characters, which are more clearly seen, however, at text-fig. 76, enlarged nine times to show the nervation.



TEXT-FIG. 76.—*Eupecopteris Fletti* Kidston n. sp. Portion of a tertiary pinna enlarged nine times to show confluent pinnules and their nervation.

In its general appearance, *Eupecopteris Fletti* has some similarity to *Pecopteris pseudo-Bucklandi* Andrae,* *Eupecopteris pteroides* Brongniart sp. (see p. 561), and *Acitheca polymorpha* Brongniart sp. (see p. 539).

From *Eupecopteris pteroides* it differs in the posterior basal pinnule being placed on the rachis of the secondary pinna and free from all connexion with the rachis of the primary pinnæ, on which the posterior basal pinnule is situated in *Eupecopteris pteroides*, in the lateral veinlets in the larger pinnules having almost invariably only three ultimate divisions, in the lateral veinlets of a few of the pinnules at the apex of the secondary pinnæ and of the pinnules on the secondary pinnæ at the apex of the primary pinnæ being only once divided, and in the main rachis of the frond and the rachises of the primary pinnæ being densely apiculate.

From *Scolecopteris polymorpha* it is distinguished by its less-divided lateral veinlets, the rounded corners of the base of the pinnules, which are never decurrent and always free (except the two or three small pinnules at the extreme apex of the pinnæ), and by its densely apiculate rachises.

It differs from *Pecopteris pseudo-Bucklandi* Andrae, to which perhaps it has close superficial resemblance, in the pinnules being free and slightly rounded at the base, never decurrent, in the lateral veinlets having only three ultimate branches, and the densely apiculate rachises. The pinnules of *Pecopteris pseudo-Bucklandi* are described by ANDRAE as being "elongate, at the base being neither expanded (verbreitert) nor rounded on both sides, and the lateral veinlets seem to be divided into a greater number of branchlets."

But according to ZEILLER's figures of *Pecopteris pseudo-Bucklandi*, the pinnules were decurrent on their posterior side, with a slight sinus at their base on their anterior side,† or united to each other by the bases,‡ but these characters

* "Verstein. d. Steinkohlengebirges von Wettin und Löbejün," fasc. 8, p. 106, pl. xxxvii, 1853.

† ZEILLER, "Bassin houil. et perm. de Blanzy et du Creusot," fasc. 2, "Flore foss.," p. 47, pl. xiv, fig. 1, 1906 (*Études Gîtes Min. France*).

‡ ZEILLER, "Bassin houil. et perm. de Brive," fasc. 2, "Flore foss.," p. 21, pl. v, fig. 5, 1892 (*Étude Gîtes Min. France*).

only further separate *Eupecopteris Fletti* from *Eupecopteris pseudo-Bucklandi* Andrae sp.

Distribution.—*Eupecopteris Fletti* is a rare species, and has only been recorded from the Radstock Group of the Radstockian Series.

RADSTOCKIAN SERIES.

RADSTOCK GROUP.

Horizon: ?. *Localities:* Radstock, Somerset; Wellsway Pit, near Radstock, Somerset; Camerton, 2 miles north of Radstock, Somerset.

Eupecopteris Camertonensis Kidston n. sp.

Plate CXV, figs. 2, 2*a*; text-fig. 77.

Description.—Frond probably tripinnate; primary pinnæ imperfectly known. Secondary pinnæ alternate, narrow, oblong, of almost constant width till near the apex, where they contract slightly and end in a large, blunt terminal lobe. Pinnules somewhat oblique to rachis, alternate, oblong, convex, decurrent, united to each other at their base, free portion gradually narrowing and terminating in a blunt rounded apex.

Nervation: median vein straight or slightly decurrent, usually dividing at the apex into two branches, though sometimes remaining undivided; lateral veinlets ascending and dividing into two branches at or near their base; upper veinlets occasionally undivided. Fructification unknown.

Remarks.—The best example of this species that I have yet seen is shown natural size on Pl. CXV, fig. 2. It is very fragmentary and exhibits only a portion of what is most probably a primary pinna. This gives off alternate secondary pinnæ 2·5 cm. to 3 cm. in length and about 8 mm. in breadth. They are of almost equal width till the apex is reached, where the pinnæ slightly narrow and terminate in a large, blunt sub-trilobate pinnule. These can be seen on the three pinnæ indicated by the pointers. The pinnules are a little longer than broad, convex; they become gradually narrower upwards, are slightly decurrent, and united to each other at the base. The nervation is strong, the lower lateral veinlets are divided once near their base, while a few of the uppermost ones remain simple. Part of two secondary pinnæ are enlarged three times at Pl. CXV, fig. 2*a*, to exhibit more distinctly the form and the union of the pinnules to each other; a single pinnule is enlarged seven times at text-fig. 77 to show its nervation.

TEXT-FIG. 77.—*Eupecopteris Camertonensis* Kidston n. sp. Pinnule enlarged seven times to show nervation.

Eupecopteris Camertonensis has some similarity to *Senftenbergia* (*Pecopteris*) *pennæformis* Brongniart sp.,* but differs in the pinnules being larger and the pinnæ

* "Hist. des végét. foss.," p. 345, pl. cxviii, figs. 3, 4.

much broader in proportion to their length. They also end in a larger terminal pinnule, which has a small lateral lobe at its base on each side and the lateral veinlets pass out from the median vein at a more acute angle.

The specific name is derived from the village of Camerton, where the original specimen was found, a locality well known in the past to collectors of fossil plants.

Distribution.—Very few specimens of *Eupecopteris Camertonensis* are known to me; all of them are from the Radstockian Series.

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon: ?. *Locality:* Camerton, 2 miles north of Radstock.

South Wales Coalfield.

FARRINGTON GROUP.

Horizon: No. 3 Llantwit Seam. *Locality:* Castellau, near Beddau, Llantrisant, Glamorganshire (D. Davies).

Eupecopteris minor Kidston n. sp.

Plate CXXXVII, figs. 2, 2*a*, 3.

Description.—Frond quadripinnate or decompound. Primary pinnæ quadripinnate towards base of frond, tripinnate in the upper region; rachis smooth or with fine longitudinal striations. Secondary pinnæ on lower portion of frond broadly linear, of almost equal width till near the apex, where they contract into a blunt point, touching each other laterally or slightly overlapping, 4 cm. or more in length and about 2 cm. in breadth; on the upper region of the frond, the secondary pinnæ contract more gradually towards the apex. Tertiary pinnæ linear, free or touching laterally, with blunt rounded apices, about 1 cm. in length and 3 mm. in breadth, and bear 6–7 pairs of pinnules. Pinnules attached by the whole width of their base; on pinnæ of the quadripinnate region of frond alternate, small, about 1·5 mm. in length, free or united at their base, almost upright to the rachis, with straight sides and an obtusely rounded apex. On the tripinnate condition of the primary pinnæ the pinnules are larger, about 3·5 mm. in length and 2 mm. to 2·5 mm. in breadth, free or slightly united at the base, frequently touch each other laterally, have straight sides and an obtusely rounded apex.

Nervation not distinctly seen. Fructification unknown.

Remarks.—I have received on several occasions from Mr John Smith, of Dalry, specimens of a *Eupecopteris* from the Ayrshire Coalfield, with small pinnules. The late R. Dunlop also showed me examples of the same plant from the Lanarkshire Coalfield. The specimens were very fragmentary and not well preserved, but the plant is so distinct from any species known to me in this group that I figure and describe here the two most perfect specimens under the name of *Eupecopteris minor*. It is of special interest from the fact that it is the only species of *Eupecopteris* or its allies found in the Lanarkian Series, and appears to be the precursor of a group, which became a dominant type in the Radstockian or Stephanian age.

At fig. 2, Pl. CXXXVII, is given what I believe to be part of a primary pinna from the basal region of the frond, where it displayed a quadripinnate condition. The secondary broadly-linear pinnæ contract suddenly at the apex and terminate in a blunt point. The tertiary pinnæ, which are also linear and have very blunt apices, bear 6–7 pairs of very small pinnules. Those on the lower-situated pinnæ appear to be free, but on the tertiary pinnæ holding higher positions they are more or less united to each other. A few of these tertiary pinnæ are enlarged two times at fig. 2*a*.

Part of a primary pinna from a higher level on the frond than that just described shows a tripinnate condition. The pinnules here are larger and on the lower secondary pinnæ are free, though they usually touch laterally. On the upper secondary pinnæ they appear to be united to each other at the base. On none of the specimens was the nervation distinctly seen, the median vein being the only part of the nervation that was visible.

In general appearance and character the plant is comparable with *Asterotheca Miltoni* Artis sp., but differs from it in being distinctly smaller in all its parts. This was a constant character of all the specimens I have seen. The secondary pinnæ are also not only smaller than the corresponding pinnæ of *Asterotheca Miltoni*, but are much broader in proportion to their length. *Eupecopteris minor*, though imperfectly known, exhibits such individual characters that it can be easily distinguished from *Asterotheca Miltoni*, which appears to be its nearest ally.

Distribution.—Eupecopteris minor is very rare, and has hitherto been found only in the Lanarkian Series.

LANARKIAN SERIES.

Ayrshire Coalfield.

Horizon: Seventeen feet below Five-quarter Coal. *Locality:* Ardeer Pit, Stevenston (J. Smith).

Lanarkshire Coalfield.

Horizon: Kiltongue Coal. *Locality:* Bent Colliery, 1½ mile east of Bothwell (R. Dunlop).

Eupecopteris Volkmanni Sauveur sp.

Plate CXXXVI, figs. 1–3, 3*a*–*c*.

1848. *Pecopteris Volkmanni* Sauveur, " Végét. foss. du terr. houil. de la Belgique," pl. xlv, figs. 1–4 (*Nouv. Mém. Acad. Roy., Brussels*).
1886. *Pecopteris Volkmanni* Zeiller, " Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 204, pl. xxviii, figs. 1–3.
1913. *Pecopteris Volkmanni* Gothan, " Oberschlesische Steinkohlenflora," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Band lxxv, Teil 1, p. 154, pl. xxxiv, fig. 5.
1915. *Pecopteris Volkmanni* Jongmans and Gothan, " Paläobot.-strat. Studien," *Archiv für Lagerstättenforschung*, No. 18 (*K. preuss. geol. Landesanst.*), p. 174, pl. v, figs. 7, 7*a*.
1882. *Cyatheites arborescens* Achepohl (*non* Schlotheim), " Niederrh.-Westfäl. Steinkohl.," p. 94, pl. xxxii, fig. 1.

Description.—Frond large, tripinnate in middle region, and quadripinnate at the base. Main rachis 12 mm. or more in breadth, roughened with numerous small point-like elevations. Primary pinnæ slightly oblique to rachis, opposite, lanceolate or oval-lanceolate, slightly narrowed at base and gradually contracting to a point at the summit, overlapping each other laterally and attaining a length of 40 cm.; rachis straight and bearing numerous small apiculi. Secondary pinnæ alternate, free or touching laterally, spreading outwards at a very open angle, lanceolate, slightly contracted at base, tapering gradually upwards for two-thirds or three-quarters of their length and terminating in a long, entire, obtuse point; rachis straight. Tertiary pinnæ alternate, linear-lanceolate, terminating in a large, entire, obtuse lobe, usually free, but sometimes touching laterally; rachis straight.

Pinnules alternate, those on the ultimate pinnæ of the central region of the frond attached by the whole width of their base, sometimes slightly decurrent and very slightly united to each other, or free and slightly contracted at base, contiguous, a little unequal in length and almost upright to the rachis; towards the apex of the pinnæ the pinnules become more or less confluent and the pinnæ terminate in a long, entire, obtuse terminal lobe. As traced towards the base of the frond the pinnules become elongated, with margins entire; at a lower level the margins become undulated, then the lower undulations are developed as lobes, and finally the pinnules assume the form of tertiary pinnæ with confluent pinnules. Towards the upper end of the primary pinnæ, the pinnules on the secondary pinnæ become smaller and gradually more and more united to each other till the secondary pinnæ are reduced to the form of entire, elongated pinnules.

Nervation usually distinct, especially on the dorsal surface. In the pinnules, on the middle region of the frond, the median vein is somewhat thick, straight, and extends to the apex, the lateral veinlets depart at an open angle and divide into two arms, the upper of which in the lower veinlets usually again forks. In the small united pinnules of the lower tertiary pinnæ the median vein is decurrent, arcuate, slightly flexuous, and gives off simple or once-divided lateral arcuate veinlets.

Fructification unknown.

Remarks.—Examples of *Eupecopteris Volkmanni* from three different regions of the frond are given on Pl. CXXXVI. That at fig. 2 belongs to the middle region of the frond. The specimen shows portions of two primary pinnæ which considerably overlap each other laterally. The secondary pinnæ are alternate, generally free, rarely touch each other laterally, and bear oblong alternate pinnules whose margins rest upon each other. The basal anterior pinnule is frequently longer than the corresponding posterior pinnule, but both are of a similar form. Sometimes the pinnules are slightly decurrent and are feebly united to each other, though many are free and contracted at the base, as seen at the enlarged figs. 2*a* and 2*b*. The pinnules on the same pinnæ are of unequal length.

The rachises of the secondary pinnæ appear to be smooth on the ventral surface, but are apiculate on their dorsal surface.

The specimen given at fig. 1, Pl. CXXXVI, which is shown natural size, held a lower position on the frond than that seen at fig. 2. Here the pinnules have become elongated, but still have entire margins. At a still lower level these elongated pinnules develop sinuous margins, and gradually the lobes assume the form of pinnules and the structure becomes a tertiary pinna.

A small specimen from the basal region of a frond is given natural size at fig. 3 to show these tertiary pinnæ, two of which are enlarged three times at fig. 3*a*. They end in long obtuse lobes, which form about one-third of their length, and on this example the pinnules are also united to each other for about the same distance. The median vein is decurrent, slightly flexuous, and gives off lateral arcuate veinlets, sometimes from both sides of the median vein, at other times from only one side. These may remain simple or fork once. Some of these confluent pinnules are enlarged six times at figs. 3*b* and 3*c* to show the nervation.

Eupecopteris Volkmanni forms a very distinct and well-characterized species. The long, obtuse terminal lobes of the pinnæ, as well as the nervation, especially of the pinnules on the pinnæ of the middle region of the frond (figs. 2*a* and 2*b*), afford good characters for the identification of the species. It is easily separated from *Dactylotheca plumosa* Artis sp. by the basal pinnule of this latter species on the posterior side of the pinna being always lobed and of a different form from that of the corresponding pinnule on the anterior side. On *Eupecopteris Volkmanni* the anterior and posterior basal pinnules are of the same form, though one may be larger than the other. The nervation also differs in the two species, and the pinnules of *Dactylotheca plumosa* taper more gradually to the apex.

ZEILLER * united with *Eupecopteris Volkmanni* the small fertile specimen described under the name of *Senftenbergia Boulayi* by STUR,† but this species has been shown by BERTRAND ‡ to belong to *Senftenbergia pennæformis* Brongniart sp. Therefore,

* ZEILLER, " Flore foss. bassin houil. de Valenciennes," p, 206.

† STUR, " Carbon-Flora d. Schatzlarer Schichten," p. 85, pl. l, fig. 1.

‡ P. BERTRAND, *Ann. Soc. géol. du Nord*, vol. lxi, p. 229, 1912.

since the fructification of *Eupecopteris Volkmanni* is unknown, its systematic position is uncertain.

Distribution.—Although *Eupecopteris Volkmanni* Sauveur sp. has an extensive vertical distribution in Britain, and has been recorded from several of the Coalfields, it is by no means a common species. There is a single record of the plant from the Blackband Group of the Staffordian Series; in the Westphalian Series it is more plentiful; while in the Lanarkian Series it has been found on only one occasion.

STAFFORDIAN SERIES.

South Wales Coalfield.

BLACKBAND GROUP.

Horizon: No. 3 Rhondda Seam. *Locality:* Glamorgan Colliery, Gilfach Goch, Glamorganshire (D. Davies).

WESTPHALIAN SERIES.

Forest of Wyre Coalfield.

Horizon: ?. *Locality:* Alton, No. 1 Boring, about 1¼ miles east of Wyre Forest Station (E. A. N. Arber).

North Staffordshire Coalfield.

Horizon: Moss Coal. *Locality:* Lane End, Fenton (W. Hind).

South Staffordshire Coalfield.

Horizon: Blue Measures above Brooch Coal. *Locality:* Jubilee Pit, Sandwell Park, West Bromwich (H. W. Hughes).

Horizon: Blue Measures, six feet above Fire-clay Coal. *Locality:* Netherton (H. W. Hughes).

Horizon: Roof of New Mine Coal. *Locality:* Mount Pleasant, Brierley Hill (H. W. Hughes).

Titterstone Clee Hill Coalfield.

Horizon: Great Coal. *Locality:* Deep Pit Mound, Clee Hill, Cutting to Belfrey Quarry, Shropshire (E. E. L. Dixon).

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Localities:* Monckton Main Colliery, near Barnsley (W. Hemingway); Woolley Colliery, Darton, near Barnsley (W. Hemingway).

Horizon: Stanley Main Seam. *Locality:* Shale Quarry, Old Roundwood Colliery, near Wakefield (S. Nettleton).

South Wales Coalfield.

Horizon: Five-foot seam (Seven-foot seam of Clydach Vale). *Locality:* Britannic Colliery, Gilfach Goch, Glamorganshire (D. Davies).

Horizon: ?. *Locality:* Shore cliff, 200 yards south of Waterwynch, 1580 yards N.E., 20 E. of Tenby Railway Station, Pembrokeshire (Collection of Geological Survey, London).

LANARKIAN SERIES.

Lanarkshire Coalfield.

Horizon: Kiltongue Coal. *Locality:* Ellismuir, Baillieston ("Dunlop Collection," Pittencrieff Museum, Dunfermline).

Eupecopteris villosa Brongniart sp.

Text-fig. 78.

1833. *Pecopteris villosa* Brongniart, "Hist. des végét. foss.," p. 316, pl. civ, fig. 3.
1869. *Pecopteris villosa* Schimper, "Traité de paléont. végét.," vol. i, p. 503.
1838. *Pecopteris ? villosa* Sternberg, "Versuch," fasc. vii–viii, p. 160.
1836. *Cyatheites villosus* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 323.
1845. *Cyatheites villosus* Unger, "Synop. plant. foss.," p. 87.
1877. *Phthinophyllum villosum* Stur, "Culm Flora," *Abhandl. k. k. geol. Reichsanst.*, Band viii, Heft 2, p. 187 (293).
1883. *Danæites villosus* Stur, "Zur Morph. u. Syst. d. Culm-u. Carbonfarne," Abth. 1, *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, p. 150 (782).

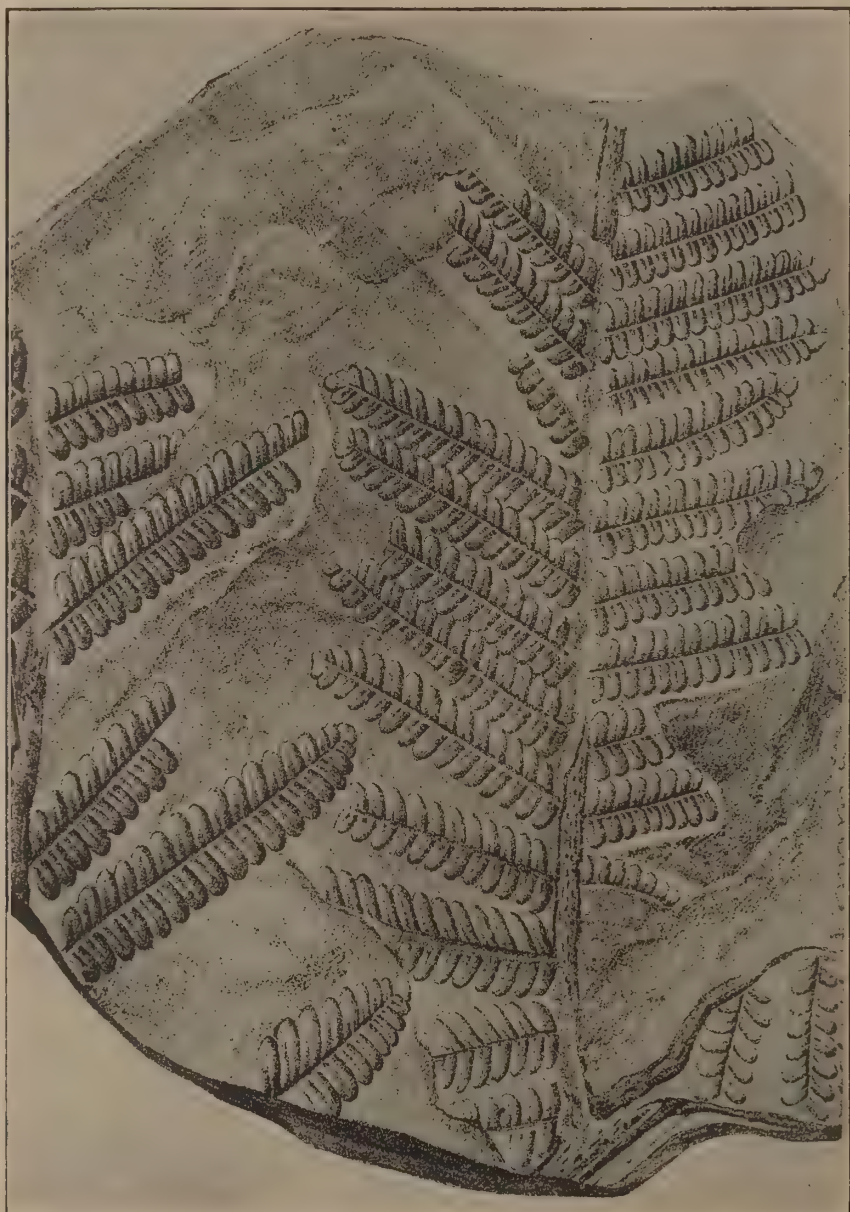
The type-specimen of *Pecopteris villosa* was collected at Camerton (Somerset), and communicated to Brongniart by Buckland. Although several palæobotanists have referred to the species, only Geinitz * has figured the specimens, which he identified with *Pecopteris villosa* Brongniart, but these are undoubtedly *Asterotheca Miltoni* Artis sp.* Although I have frequently collected fossil plants at Camerton, and have examined collections made there by others, I have never seen, either from Camerton or any locality in the Radstock portion of the Somerset and Bristol Coalfield, any specimen that could be referred to Brongniart's *Pecopteris villosa.*

Considerable doubt exists as to the validity of *Pecopteris villosa* as a distinct species. There seems to be a suspicion that it has been founded on a peculiar condition of another known species, but as the nervation was not shown on Brongniart's type-specimen, one of the most essential characters by which it could have been compared with other members of the same group is absent. It is desirable, therefore, to give here Brongniart's original diagnosis of the species. "P. foliis tripinnatifidis, rachibus paleaceis, pinnis approximatis subæqualibus linearibus bipolli-

* *Cyatheites villosus* Geinitz, "Verstein. d. Steinkf. in Sachsen," p. 25, pl. xxix, figs. 6, 7 (? fig. 8), 1855.

caribus, pinnulis usque ad rachim distinctis, totâ basi rachi adnatis, subellipticis obtusis, inferiùs dense paleaceo-villosis, paleis setaceis, nervulis non distinctis."

In his remarks on *Pecopteris villosa* Brongniart further says that the filiform



Text-fig. 78.—*Eupecopteris villosa* Brongniart sp. Part of Brongniart's original figure in the "Hist. des végét. foss.," pl. civ, fig. 3.

setaceous scales which cover all the dorsal surface of this fern, and which cover equally the common rachises of divers orders, furnish a character which easily distinguishes this species from the other fossil ferns which resemble it in the form of their pinnules and of the whole leaf. This character therefore prevents its being confounded with either *Pecopteris oreopteridia* or with *Pecopteris polymorpha*, although one is not able to observe the arrangement of the nerves, which are probably obscured by the scales. The general analogy in the form of the leaf and the pinnules has induced us to place this species next to *Pecopteris oreopteridia*.

At text-fig. 78 a part of Brongniart's figure is reproduced. The form of the pinnæ and pinnules has a great similarity to those of *Asterotheca Miltoni* Artis sp., and that it might belong to this species has been suggested by Gutbier * and Zeiller.† The form of the pinnules and the blunt obtuse secondary pinnæ correspond with those of *Asterotheca Miltoni*, but in this species the pinnules are hirsute or villose on their upper surface; and if Brongniart was correct in referring the villose surface of his specimen to the lower surface of the frond, then *Pecopteris villosa* Brongniart cannot be referred to *Asterotheca Miltoni*.

The type-specimen of *Pecopteris villosa* is still preserved in Paris, and has been examined by Zeiller,‡ who states that the nervation is absolutely indistinct and that it was also very difficult to discover any trace of the " écailles sétacées filiformes " which, according to Brongniart, cover the inferior face of the pinnules, the fossil without doubt having been altered by time.

It is therefore impossible to determine satisfactorily the specific value of *Eupecopteris villosa* Brongniart sp. A mistake may have been made in regarding the exposed surface of the pinnules as showing their dorsal surface, but this we have no means of ascertaining. The true relationship of *Eupecopteris villosa* Brongniart sp. to *Asterotheca Miltoni* Artis sp. must therefore be left an open question.

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon : ?. *Locality :* Camerton, 2 miles north of Radstock, Somerset. (Type of the species.)

Genus **Pecopteris** Brongniart (emend.).

1822. *Filicites* (*Pecopteris*) Brongniart (*pars*), " Classif. des végét. foss.," *Mém. Museum d'Hist. nat.*, vol. viii, p. 33.
1826. *Pecopteris* Sternberg (*pars*), " Essai flore monde prim.," vol. i, fasc. iv, p. xvii.
1828. *Pecopteris* Brongniart (*pars*), " Prodrome," p. 54.
1833. *Pecopteris* Brongniart (*pars*), " Hist. des végét. foss.," p. 267.
1849. *Pecopteris* Brongniart (*pars*), " Tableau des genres de végét. foss.," *Dict. univ. d'Hist. nat.*, vol. xiii, p. 52.

Description.—Form-genus. Frond bi-tripinnate or pinnæ elongate, pinnatifid, with pinnules adhering by the whole width of their base to the rachis or sometimes

* " Gäa von Sachsen," Herausgegeben von H. B. Geinitz, p. 82, 1843.

† " Notes sur la flore houil. des Asturies," *Mém. Soc. géol. du Nord*, Séance 7, Dec. 1881, *Pecopteris abbreviata*, pp. 12–14, 1882. (*Pecopteris abbreviata* Brongniart is synonymous with *Asterotheca Miltoni* Artis sp.)

‡ *Loc. cit.*, p. 13.

slightly contracted below and often united to each other to a greater or less extent, contiguous or almost contiguous, and sometimes decurrent. A single vein enters the pinnules, and extends almost to the apex and gives off simple, bifurcate or rarely trifurcate lateral veinlets. Fructification unknown.

Remarks.—With slight modification, the above description is copied from BRONGNIART's "Tableau des genres de végétaux fossiles." As stated in the general remarks on "*Pecopteris* Brongniart," the genus is here restricted for the reception of those species of *Pecopteris* Brongniart whose fructification is unknown, and the form of whose pinnules and the nervation differ in some way from those of the species included in the genus *Eusphenopteris*. The essential generic characters are the attachment of the pinnule to the rachis by a broad base; the pinnules may be free and even slightly contracted at base or decurrent and more or less united to each other; only a single vein enters them from the rachis, and gives off the lateral veinlets. The nervation is frequently of the sphenopteroid type and generally more lax than in the genera *Asterotheca, Ptychocarpus, Acitheca,* and *Eusphenopteris.* It is not to be inferred, however, that the species placed in the genus have any natural affinity to each other. It is merely a provisional form-genus, and probably contains both Ferns and Pteridosperms.

Distribution.—In Britain the genus is found only in Upper Carboniferous rocks.

Pecopteris Armasi Zeiller.

Plate CXXXV, figs. 2, 2*a*, and 2*b*; text-figs. 79, 80.

1897. *Pecopteris Armasi* Zeiller, "Observations sur quelques Fougères des Dépôts houil. d'Asie Mineure," *Bull. Soc. bot. France*, vol. xliv, p. 199.

1899. *Pecopteris Armasi* Zeiller, "Etude sur la flore foss. du bassin houil. d'Héraclée (Asie Mineure)," *Mém. Soc. géol. France, Paléont.*, xxi, p. 35, pl. iii, figs. 12–16.

1912. *Alethopteris Armasi* Franke in POTONIÉ, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. viii, No. 160, figs. 2, 3 (? fig. 1).

1923. *Alethopteris Armasi* Gothan in GÜRICH, "Leitfossilien," Lief. 3, p. 59, pl. xx*a*, fig. 2.

Description.—Frond at least tripinnate, probably quadripinnate in lower region. Primary pinnæ 30 cm. to 40 cm. in length and 15 cm. to 20 cm. in breadth, rachis straight, longitudinally striated, and 2 mm. to 4 mm. in breadth. Secondary pinnæ alternate or sub-opposite, oblique to rachis, linear-lanceolate, free or slightly touching laterally, frequently contracted very slightly, gradually tapering upwards from about the middle, and ending in a blunt, oblong, terminal lobe; 8 cm. to 10 cm. or more in length, with a breadth of from 8 mm. to 2 cm. Pinnules alternate, standing upright to rachis or very slightly oblique, entire, sides almost parallel, but narrowing very gradually from the base to their rounded apex, and slightly united to each other at the base. On the secondary pinnæ situated towards the base of the primary pinnæ, the basal posterior pinnule is placed in the angle formed by the union of the secondary and primary rachises. As the secondary pinnæ are traced towards the apex of the primary pinnæ, their basal posterior pinnule gradually passes downwards until it goes entirely from the rachis of the secondary pinnæ and occupies a place on the rachis of the primary pinnæ. Towards the apex of the primary pinnæ, the pinnules on the secondary pinnæ become more and more united to each other, until the secondary pinnæ have only an undulating margin or are even entire and assume the form of pinnules.

Nervation strong, distinct, median vein straight or slightly decurrent at base; lateral veinlets ascending, given off at an acute angle, and almost immediately divide into two branches, which again generally divide except towards the upper end of the pinnule, where they are usually only once divided. The ultimate divisions of the veinlets meet the margin of the pinnule more or less obliquely. The two basal lateral veinlets on each side of the median vein spring from its extreme base, and that on the anterior margin runs parallel with the rachis, while the other is more ascending; lateral veinlets are only given off from their anterior side.

Remarks.—The only British example of *Pecopteris Armasi* that I have seen forms the subject of Pl. CXXXV, fig. 2. It was collected by Mr W. Hemingway, to whom I am indebted for the specimen. It is shown natural size at fig. 2.

The specimen is part of a primary pinna, the axis of which is only preserved in part, but is rather over 2 mm. in breadth and bears fine longitudinal striations. The secondary pinnæ are opposite at the upper end of our example, but gradually become sub-alternate at the base. They are linear-lanceolate, and taper gradually upwards from about two-thirds their length above the base, and terminate in an oblong obtuse lobe, while the lower third of the pinna frequently contracts slightly downwards.

The pinnules are oblong, united to each other, and usually become very slightly and gradually narrower from the base upwards, and end in bluntly rounded apices. On our specimen their length is about twice the breadth at the base, or slightly more. On secondary pinnæ holding higher positions, the pinnules become shorter in proportion to their breadth, and eventually become more and more united to each other until they merely form a crenate margin to the pinnæ, which finally become entire and assume the form of pinnules (text-fig. 79).

Zeiller has shown that the basal posterior pinnule on the lower-situated secondary pinnæ, which occupies the angle formed by the union of the secondary and primary pinnæ, gradually alters its position on the upper secondary pinnæ, and by slow degrees gradually passes on to the rachis of the primary pinnæ, to which it eventually becomes entirely attached.

An apex of a primary pinna, copied from Zeiller,* but enlarged two times, is given at text-fig. 79, where at x, x, two of the basal pinnules are seen to have crept on to the rachis of the primary pinna, to which they are now completely attached.

The nervation is very well seen on the specimen given at fig. 2, Pl. CXXXV,

* *Op. cit.* (Mem. 21), pl. iii, fig. 13.

and a part of a secondary pinna is enlarged three times at fig. 2*a*. In the larger pinnules the median vein seems to be always slightly decurrent at the base, but in the specimens figured by ZEILLER it is usually straight. This decurrence of the median vein seems to hold a direct relationship to the extent of union which has taken place among the pinnules.

TEXT-FIG. 79.—*Pecopteris Armasi* Zeiller. Apical portion of a primary pinna. Enlarged two times. After ZEILLER.

To show the nervation distinctly, a pinnule is enlarged six times at fig. 2*b*, Pl. CXXXV, and another is enlarged seven times at text-fig. 80. The basal lateral veinlet on each side of the median vein springs from its extreme base; that on the posterior side takes a slightly more ascending course than that on the anterior side. The latter runs parallel with and close to the rachis, and both give off veinlets from the side facing the apex of the pinnule only. This peculiar arrangement of the two lateral basal veinlets has been emphasized by ZEILLER, who clearly pointed out, in his description of the species, that the pinnules derive no veinlets from the rachis of the pinna, though in imperfectly preserved specimens these veinlets might be thought to be derived from it. These basal veinlets are clearly seen on our specimen, as shown in the enlarged pinnule on Pl. CXXXV, fig. 2*b*, and at text-fig. 80. The lateral veinlets at the apex of the pinnule are usually divided only once, but the lower ones generally divide twice, with the exception of those springing from the basal pair, which are sometimes undivided. The veinlets take a very oblique ascending course to the margin of the pinnule.

TEXT-FIG. 80.—*Pecopteris Armasi* Zeiller. Pinnule enlarged seven times to show the nervation.

Dr FRANKE, in his description of *Pecopteris Armasi* Zeiller, describes the pinnules as receiving some veinlets direct from the rachis, as in *Alethopteris*, and places the plant in that genus. The nervation in our specimen is undoubtedly as represented in the two enlarged outline drawings of pinnules, which confirm in every respect the description given by ZEILLER. If therefore the enlarged figure given by Dr FRANKE as an inset to his fig. 1 (*loc. cit.*) is a correct representation of the nervation of his specimen, then I am afraid it cannot be the *Pecopteris Armasi* of Zeiller.

Zeiller has made some very suggestive remarks as to *Pecopteris Armasi* forming a " type of passage " between the " true " *Pecopteris* and the genus *Callipteridium*. From the latter genus it differs in the veinlets being less oblique and less numerous, and in all being derived from the median vein; and though at the apical region of the primary pinnæ the posterior basal pinnule has passed on to the rachis of the primary pinna. On the lower regions of the primary pinnæ, the rachis between the secondary pinnæ is " naked " and does not bear pinnules as in *Callipterdium*, it therefore cannot be included in that genus.

The arrangement of the nervation is certainly unusual, but not so much so as to exclude it from the form-genus *Pecopteris*, in which Zeiller placed it.

The geological distribution of *Pecopteris Armasi* also corresponds to these suggested relationships, which, however, are only to be regarded as indicating the possible affinity of the plant.

From the genus *Alethopteris* it is at once distinguished by the absence of any veinlets passing directly from the rachis into the pinnule.

In specimens showing the nervation, it would be difficult to confuse *Pecopteris Armasi* with any other species, but if the lateral basal veinlets were imperfectly preserved, especially that on the side of the pinnule which lies parallel with and close to the rachis, it might be mistaken for an *Alethopteris*.

Distribution.—Pecopteris Armasi, though it has a very wide horizontal distribution, is a very rare species. I have seen only one British specimen, which was obtained from the Radstockian Series.

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon : ?. *Locality :* Wellsway Pit, Radstock, Somerset (W. Hemingway).

Pecopteris integra Andrae sp.

Plate CXXXVII, figs. 4 and 4*a* ; text-fig. 81.

1849. *Sphenopteris integra* Andrae in Germar, " Verstein. d. Steinkohl. v. Wettin u. Löbejün," p. 67, pl. xxviii.

1869. *Pecopteris integra* Schimper, " Traité de paléont. végét.," vol. i, p. 530.

1886. *Pecopteris integra* Zeiller, " Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 211, pl. xxv, fig. 5.

1888. *Pecopteris integra* Zeiller, " Flore foss. terr. houil. de Commentry," pt. 1, *Bull. Soc. Ind. Min.*, ser. 3, vol. ii, livr. 2, p. 160, pl. xvii, fig. 2.

1906. *Pecopteris integra* Zeiller, " Bassin houil. et perm. de Blanzy et du Creusot," fasc. 2, " Flore Fossile," *Études Gîtes Min. France*, p. 49, pl. xiv, fig. 2.

Description.—Frond of large size, at least tripinnate. Principal rachis marked with more or less fine irregular striæ. Primary pinnæ alternate or sub-opposite, touching each other laterally, lanceolate or linear-lanceolate, tapering at the summit and ending in an obtuse point, attaining a length of 40 cm. or more, with a straight rachis 7 mm. or more in breadth. Secondary pinnæ alternate, touching each other laterally or slightly overlapping, linear-lanceolate, gradually contracting from the base upwards, terminating in an obtuse point, and reaching a length of 10 cm., rachis straight. Towards the apex of the frond the primary pinnæ assume the form of secondary pinnæ, and finally, through the more or less complete union of the pinnules, become crenulate, then entire, and assume the form of pinnules.

Pinnules alternate, oblique to rachis, contiguous, oval-linear, rounded at the apex, distinctly decurrent on the inferior margin and slightly united to each other, more or less contracted on the anterior margin through a sinus which cuts more or less deeply into the pinnule according to the position held by the pinnules on the pinna and the position of the pinna on the frond. In the pinnules on the basal portion of the secondary pinnæ, situated on the lower region of the frond, the sharp-pointed sinus extends inwards almost to the median vein, so that the pinnule is only attached to the rachis by little more than half its entire width. On the pinnules holding higher positions on the secondary pinnæ, the sinus extends less and less into the pinnule, when they become attached to the rachis by a corresponding broader base. Towards the upper end of the secondary pinnæ the pinnules become more united to each other, and at the apex are only indicated individually by a rounded lobe. The basal pinnules sometimes have one or two obtuse lobes. The pinnule on the posterior side is attached to the extreme base of the rachis, and fills up the angle formed at the junction of the primary and secondary pinnæ. The limb of the pinnules seems to have been formed of delicate tissue.

Nervation: median vein very decurrent, lateral veinlets departing at an acute angle, usually dividing twice. The posterior basal veinlet springs from the extreme base of the median vein, and the anterior basal veinlet runs parallel with the margin of the sinus.

Fructification unknown.

Remarks.—The only British example of this species that I have seen is the small specimen given natural size on Pl. CXXXVII, fig. 4, which is enlarged two times at fig. 4*a*. It shows part of a primary pinna (or frond) from near the apex, and agrees with pinnæ from the same region of the frond as figured by Andrae. On our specimen the sinus on the anterior margin of the pinnules is very slightly developed, and it is only on the pinnules situated on pinnæ holding lower positions than our example that the sinus extends inwards to near the median vein and separates the base of the pinnule from the rachis. The lateral veinlets are not very distinctly seen on our specimen, though the stronger decurrent median vein is well shown.

An enlarged view of a pinnule from a secondary pinna which has held a lower position on the frond than our small example is given at text-fig. 81. It shows the sinus extending inwards and separating the anterior portion of the limb from the rachis and also the nervation, which is of the sphenopteroid type.

POTONIÉ * has proposed the union of *Pecopteris integra* Andrae sp. with *Crossotheca pinnatifida* Gutbier sp.,† but these two plants appear to be essentially distinct. *Pecopteris integra* never has the neuropteroid form of pinnule seen on *Crossotheca pinnatifida*, nor has the latter the deep sinus which cuts in and partially separates the limb from the rachis on its anterior margin. As the relationship of these two species has been fully dealt with by ZEILLER,‡ the question need not be further discussed here.

Pecopteris integra Andrae sp. is easily separated from the other members of the genus by its oblique decurrent pinnules with a deep ingoing sinus at the base of the anterior margin, by its decurrent median vein and sphenopteroid lateral veinlets.

TEXT-FIG. 81.—*Pecopteris integra* Andrae sp. Pinnule enlarged to show sinus and nervation. From ANDRAE in GERMAR, pl. xxviii, fig. 4.

As pointed out by SCHIMPER,§ the figure published by GÖPPERT || (without description) under the name of *Sphenopteris integra* is specifically distinct from ANDRAE's species of that name.¶

I am indebted to Mr D. DAVIES for the specimen which is here figured and described.

Distribution.—The only British specimen of this species, so far as I am aware, is that which forms the subject of our figure.

RADSTOCKIAN SERIES.

FARRINGTON GROUP.

Horizon: No. 2 Llantwit Seam. *Locality:* Graiglas, Gilfach Goch, Glamorganshire (D. DAVIES).

Pecopteris Bioti Brongniart.

Plate XCVI, figs. 4, 4*a*.

1836. *Pecopteris Biotii* Brongniart, " Hist. des végét. foss.," p. 344, pl. cxvii, fig. 1.
1845. *Pecopteris Biotii* Unger, " Synop. plant. foss.," p. 97.
1869. *Pecopteris Biotii* Schimper, " Traité de paléont. végét.," vol. i, p. 519.
1836. *Aspidites Biotii* Göppert, " Syst. fil. foss.," p. 364.
1869. *Cyatheites Bioti* Weiss, " Foss. Flora d. jüngst. Stk. u. Rothl.," p. 70.
1877. *Senftenbergia Biotii* Stur, " Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, pp. 293, 298 (*non* fig. 29, p. 295).
1877. *Pecopteris* (*Prepecopteris*) *Biotii* Grand'Eury, " Flore Carb. du Dépt. de la Loire," *Mém. Acad. Sci. Paris.*, xxiv, no. 1, p. 63.

Description.—Frond tripinnate, rachis straight. Primary pinnæ alternate, lanceolate, placed close to each other, with their margins touching or separated by

* " Flora d. Rothl. von Thüringen," *Abhandl. k. preuss. geol. Landesanst.*, Heft 9, p. 91, 1893.

† See *ante*, p. 349.

‡ ZEILLER, " Bassin houil. et perm. de Blanzy et du Creusot," p. 48, 1906.

§ SCHIMPER, " Traité de paléont. végét.," vol. i, p. 530, 1869.

|| GÖPPERT, " Foss. Flora d. Perm. Formation," pl. x, figs. 3, 4, 1864.

¶ SCHIMPER thought the specimen was referable to *Asterotheca oreopteridia* Schlotheim sp., but the enlarged figure of the pinnules shows them to be more decurrent than in that species (" Traité de paléont. végét.," vol. i, p. 530, 1869).

a small space; rachis straight. Secondary pinnæ alternate, longer on anterior side, lanceolate, free or touching laterally, oblique; rachis straight and bearing six tc eight pairs of pinnules. Pinnules alternate, oblique to rachis, broadly lanceolate, entire and united to each other for a quarter to a third of their length, obtuse or with a blunt point, terminal pinnule obtuse, with sometimes a few blunt teeth. As the secondary pinnæ are traced upwards the pinnules become more and more united to each other, and at the apex assume the form of elongated, entire pinnules. The nervation consists of a single vein passing up the middle of the pinnule.

Remarks.—The only specimen of *Pecopteris Bioti* Brongniart that I have seen is shown on Pl. XCVI, fig. 4, of which a pinna is enlarged three times at fig. 4*a* to show the form of the pinnules.

The primary pinnæ are of almost constant width in their lower part, then gradually taper to a point. The secondary pinnæ are also of almost equal width till near the apex, where they contract into an obtusely pointed terminal lobe; those on the posterior side of the rachis are distinctly shorter than those on the anterior side. The pinnules are of almost equal size till near the top of the pinnæ; they are oblique to the rachis, with entire margins, and united to each other. Some have fairly sharp points, as seen in the enlargement (fig. 4*a*), but on others the apex is more obtuse. The basal posterior pinnule occupies the angle formed by the union of the primary and secondary rachises and is partly attached to both. The pinnules on our specimen and on that figured by Brongniart show only a median vein.

Pecopteris Bioti differs from *Dactylotheca plumosa* in the pinnules being always entire, more or less distinctly united to each other, and, so far as observed, in only having a median vein. The ultimate pinnæ on the two sides of the rachis are also of unequal size, especially towards the base of the penultimate pinnæ. A comparison of specimens of the form of *Dactylotheca plumosa*, which approaches most closely to *Pecopteris Bioti*, such as those given on Pl. XCIV, figs. 1 and 2, will show better than words the distinctive character and appearance of the two plants.

From an examination of the specimens figured by Zeiller under the name of *Pecopteris Bioti*,* I feel satisfied that they belong to *Dactylotheca plumosa* Artis sp., and are not *Pecopteris Bioti* Brongniart.

Distribution.—The only known British example of this species was collected by Mr W. Hemingway, to whom I am indebted for the specimen.

WESTPHALIAN SERIES.

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley (Kidston Collection, No. 2245).

* "Flore foss. terrain houil. de Commentry," pt. 1, p. 99, pl. ix, figs. 1, 2, 1888.

Pecopteris ? hepaticæformis Kidston.

Plate XCVI, figs. 5, 5*a*.

1914. *Pecopteris ? hepaticæformis* Kidston, "Foss. Flora Westphal. Series, South Staffordshire," *Trans. Roy. Soc. Edin.*, vol. l, p. 99, pl. vii, figs. 7, 7*a*.

Remarks.—A fragment of a very small pinnuled plant is shown natural size on Pl. XCVI, fig. 5, and two pinnules are enlarged ten times at fig. 5*a*. The larger fragment is about 11 mm. in length and about 1·5 mm. in breadth at its base, whence it decreases very gradually in width upwards. The specimen is converted into a very black carbonaceous substance, which seems to indicate that the pinnules must have been of considerable thickness. The nervation is not observable.

The systematic position of this little plant is very doubtful. The form and attachment of the pinnules are similar to those of *Pecopteris*, and on that account it is provisionally placed in that form genus.

[I have also received from Mr W. Hemingway two small fragments of a similar small pinnuled plant, on which five ultimate pinnæ spring at right angles from a delicate rachis. They are parallel to each other and separated by a short space. The only complete pinna is 9 mm. in length and bears nine pairs of free, alternate pinnules with obtuse apices. The width of the pinnæ is rather under 2 mm. The manner in which the ultimate pinnæ spring from the rachis is very fern-like. The plant is similar in general form to *Pecopteris ? hepaticæformis*, but the pinnules are slightly more distant, and with straighter sides. These differences, however, may be due to the specimens having come from different regions of the frond. Mr Hemingway's specimens were collected at the Oaks Colliery, Barnsley, and their horizon is 90 yards below the Barnsley Coal, Westphalian Series (Kidston Collection, Nos. 2179 and 2180).]

WESTPHALIAN SERIES.

Horizon: Ten-foot Ironstone Measures. *Locality:* ? Coseley, near Dudley (in the Collection of the late Sir Charles Holcroft).

Genus Callipteridium Weiss.

Text-figs. 82, 83.

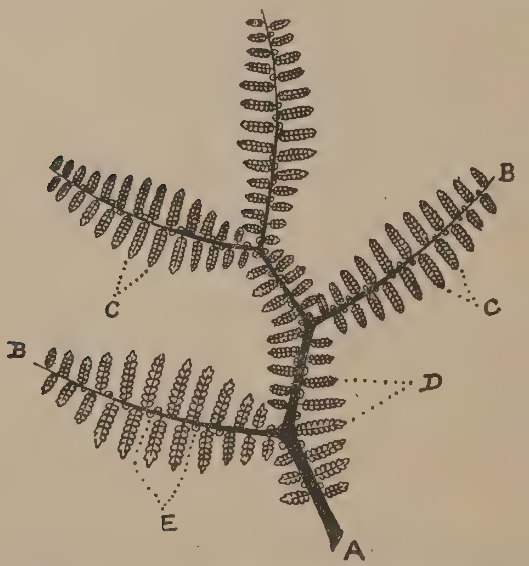
1828. *Pecopteris* Brongniart (*pars*), "Prodrome," p. 54.
1833. *Pecopteris* Brongniart (*pars*), "Hist. des végét. foss.," p. 267.
1869. *Neuropteridium* Weiss (*non* Schimper), "Foss. Flora d. jüngst. Steink. u. Rothl.," p. 28.
1870. *Callipteridium* Weiss, "Studien über Odontopteriden," *Zeitschr. deutsch. geol. Gesellsch.*, Band xxii, p. 588.

1888. *Callipteridium* Zeiller, "Flore foss. terr. houil. de Commentry," *Bull. Soc. Ind. Min.*, ser. 3, vol. ii, livr. 2, p. 193.
1890. *Callipteridium* Zeiller, "Bassin houil. et perm. d'Autun et d'Épinac," fasc. 2, "Flore Fossile," *Études Gîtes Min. France*, p. 75.
1900. *Callipteridium* Zeiller, "Éléments de paléobotanique," p. 91.
1906. *Callipteridium* Zeiller, "Bassin houil. et perm. de Blanzy et du Creusot," fasc. 2, "Flore Fossile," *Études Gîtes Min. France*, p. 64.
1910. *Callipteridium* Seward, "Fossil Plants," vol. ii, p. 560.
1921. *Callipteridium* Gothan in Potonié "Lehrb. d. Palaeobotanik" (Zweite Auflage), pp. 73, 95.

Description.—Frond tripinnate. Main rachis of the frond bears between the primary pinnæ small pinnate pinnæ. Rachis of primary pinnæ bears between the secondary pinnæ simple pinnules directly attached to it. Pinnules on secondary pinnæ alternate or sub-opposite, attached by all their base, often slightly united to each other, their margins parallel or contracting gradually upwards, entire, rounded or blunt-pointed at apex.

Median vein distinct, but subdividing into veinlets before reaching the apex of the pinnule; lateral veinlets given off at a more or less open angle, dichotomizing once or several times at an acute angle. Veinlets at base of pinnule enter it direct from the rachis. Fructification unknown.

Remarks.—The general structure of the frond of *Callipteridium* is seen at text-fig. 82, which gives a much-reduced sketch of part of the fine specimen of *Callipteridium pteridium* figured by Zeiller.* *A* is the main rachis of the frond, *B*, *B* the primary pinnæ, *C*, *C* the secondary pinnæ, *D* the small simple pinnæ borne on the main rachis of the frond between the primary pinnæ, and *E* the pinnules on the rachis of the primary pinnæ between the secondary pinnæ on which the usual pinnules are borne. A larger view of part of a primary pinna is given at text-fig. 83. *C*, *C* are the secondary pinnæ; *E* the pinnules placed on the rachis of the primary pinnæ between them and *F* of the normal pinnules.



Text-fig. 82.—*Callipteridium pteridium* Schlotheim sp. Ramification of frond. After Gothan in Potonié "Lehrbuch der Paläobotanik." Very much less than natural size.

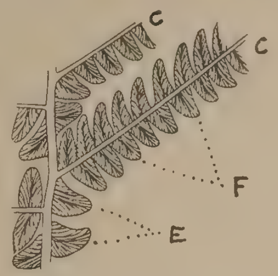
Zeiller described the structure of the frond as composed of successive dichotomies of asymmetrical branches, forming alternately the one a continuation of the rachis, the other a lateral pinna.

Some authors have allied the genus *Callipteridium* to *Alethopteris*, others to *Odontopteris*. It differs from *Alethopteris* in the pinnules not being decurrent or

* Zeiller, "Flore foss. terr. houil. de Commentry," pl. xix, fig. 1.

at the most they are only so to a very slight degree. The genus *Alethopteris* differs further in the absence of small accessory pinnæ on the rachises between the normal pinnæ. From *Odontopteris, Callipteridium* is at once separated by the presence of a prominent median vein in the pinnules.

Isolated secondary pinnæ of *Callipteridium* have a great similarity to those of *Asterotheca* and some allied pecopteroid genera, but are easily distinguished from them by the veinlets in the lower part of the pinnules being derived directly from the rachis as in *Alethopteris.*



TEXT-FIG. 83.—*Callipteridium pteridium* Schlotheim sp. Portion of a primary pinna, reduced to three-quarters the natural size. From ZEILLER'S "Éléments de Paléobotanique."

The genus *Callipteridium* is extremely rare in Britain. The only example I have seen is a single secondary pinna of *Callipteridium gigas* Gutbier.

The systematic position of the genus *Callipteridium* is undetermined.

Distribution.—Our only British record for the genus is from the Farrington Group of the Radstockian Series.

Callipteridium gigas Gutbier sp.

Plate CXXX, figs. 2, 2*a* ; text-fig. 84.

1849. *Pecopteris gigas* Gutbier, " Verstein. d. Zechsteingebirges d. Rothliegenden," p. 14, pl. vi, figs. 1–3 (? pl. ix, fig. 7).

1858. *Alethopteris gigas* Geinitz, " Leitpflanzen d. Rothl. u. d. Zechsteingebirges," p. 12, pl. i, figs. 2, 3 (Oster-Programm d. königl. polytech. Schule zu Dresden).

1870. *Callipteridium gigas* Weiss, " Studien über Odontopteriden," *Zeitschr. deutsch. geol. Gesellsch.*, Band xxii, p. 879.

1886. *Callipteridium gigas* Sterzel, " Flora d. Rothl. im nordwest. Sachsens," *Palaeont. Abhandl.*, Band iii, Heft 4, p. 49 (283), pl. vii (xxvii), fig. 4.

1888. *Callipteridium gigas* Zeiller, " Flore foss. terr. houil. de Commentry," pt. 1, *Bull. Soc. Ind. Min.*, ser. 3, vol. ii, livr. 2, p. 199, pl. xx, figs. 1–3.

1890. *Callipteridium gigas* Zeiller, " Bassin houil. et perm. d'Autun et d'Épinac," fasc. 2, " Flore Fossile," *Études Gîtes Min. France*, p. 78, pl. ix, fig. 4.

1890. *Callipteridium gigas* Grand'Eury, " Géol. et paléont. du bassin houil. du Gard," p. 292, pl. xix, figs. 2–4.

1893. *Callipteridium gigas* var. *minor* Sterzel, " Flora d. Rothl. im Plauenschen Grunde bei Dresden," *Abhandl. Math.-Phys. Cl. k. sächs. Gesellsch. d. Wissensch.*, Band xix, p. 128.

1895. *Callipteridium gigas* Sterzel, " Flora d. Rothl. von Oppenau," *Mitt. badischen geol. Landesanst.*, Band iii, Heft 2, p. 275, pl. viii, figs. 1–5.

1906. *Callipteridium gigas* Zeiller, " Bassin houil. et perm. de Blanzy et du Creusot," Fasc. 2, " Flore Fossile," *Études Gîtes Min. France*, p. 66, pl. xvii, fig. 1.

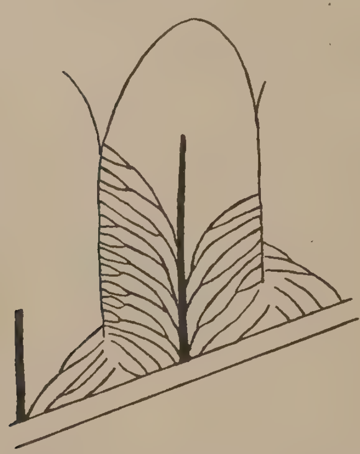
1912. *Callipteridium gigas* Franke, " Beitr. z. Kennt. d. paläoz. Arten v. *Alethopteris* u. *Callipteridium*," Inaug.-Dissert., p. 112, figs. 1, 2.

1913. *Callipteridium gigas* Franke in POTONIÉ, " Abbild. u. Beschreib. foss. Pflanzen-Reste " (*K. preuss. geol. Landesanst.*), Lief. ix, No. 180.

Description.—Fronds very large, probably tripinnate. Primary rachis . . .; secondary rachis 4–15 mm. in breadth and marked with very fine longitudinal striæ. Primary pinnæ ovate-lanceolate, tapering to a point at the summit, contracted at the base, attaining a length of from 80 cm. to 1 metre and 40 cm. in breadth. Secondary pinnæ alternate, spreading outwards or slightly directed forwards, touching at their margins or slightly distant, linear-lanceolate, tapering to a blunt point, 10 to 25 cm. in length and 2·5 cm. to 4·5 cm. in breadth. Pinnules alternate or sub-opposite, standing almost upright to rachis, often slightly scythe-shaped and bent forward in upper part, contiguous, their margins generally touching laterally till very near their apex, free or slightly united to each other at their base; margins parallel, rounded, or obtusely pointed at the summit, three and a quarter to four times longer than broad, with a length of 1 to 2·5 cm. and a breadth of 4 to 8 mm.; terminal pinnule oval-linear, very narrow, a little longer than those that precede it. The primary rachis bears between each two consecutive secondary pinnæ two or three pinnules attached directly to the rachis.

Nervation generally distinct: median vein placed in a little hollow, distinct, not decurrent at the base, arcuate in its upper part, and breaking up into veinlets at the apex; secondary veins numerous, very close, arising at an angle of 30° to 50°, arcuate and dividing many times by dichotomizing at an acute angle; veinlets at the base enter the pinnule directly from the rachis.

Remarks.—As the only specimen of *Callipteridium gigas* Gutbier sp. which I have yet seen in Britain is the part of a secondary pinna given natural size on Pl. CXXX, fig. 2, of which a few pinnules are enlarged three times at fig. 2*a*, I have taken the description of the species from Zeiller's account.*



Text-fig. 84.—*Callipteridium gigas* Gutbier sp. Pinnule enlarged six times to show the nervation. Collection of Geological Survey, London, No. 47514.

Our small example shows the greater portion of secondary pinna, from which, however, the extreme apex and probably a small portion of the base are absent. It is well preserved and shows clearly the form and the attachment of the pinnules and their nervation. The pinna is lanceolate, its central portion is of about equal width, but beyond this it gradually contracts upwards into a point; it also contracts slightly towards the base, hence the largest pinnules occupy the middle area of the pinna.

The pinnules are sessile, touch each other laterally, and are slightly united by the base; their upper part has a slight forward curve. The median vein is moderately thick and extends to within a short distance of the apex, where it loses itself in dichotomous veinlets. The lateral veinlets are numerous, close, bend quickly outwards, and divide into two to six veinlets before reaching the margin (text-fig. 84).

In the size of the pinna and pinnules, our specimen is similar to the example given by Gutbier,† which has been distinguished by Sterzel ‡ as var. *minor*.

* "Flore foss. bassin houil. de Commentry," p. 199.

† *Loc. cit.*, pl. vi, fig. 2.

‡ "Flora d. Rothl. im Plauenschen Grunde bei Dresden," p. 128, 1893.

Callipteridium gigas Gutbier sp. is distinguished from *Callipteridium pteridium* Schlotheim sp.* in its larger size, the closeness of its pinnules, with their more numerous, closer, and more-divided lateral veinlets, which also run in a straighter course to the margin of the pinnule.

The general build of the frond was probably the same in both species. (See text-fig. 82.)

GUTBIER described the fructification as "*Asterocarpus*," but this description does not appear to have been accepted, and is apparently supposed to rest on an erroneous observation.

Distribution.—Very rare. The only specimen known from Britain is that which forms the subject of our figure.

RADSTOCKIAN SERIES.

SOUTH WALES COALFIELD.

FARRINGTON GROUP.

Horizon: Wernffraith Seam. *Locality:* Bevan's Drift (abandoned), about 1 mile north of Neath Station, Glamorganshire (Specimen in Collection of Geological Survey, London, No. 47514).

Genus **Mariopteris** Zeiller.

1828. *Sphenopteris* Brongniart (*pars*), " Prodrome," p. 50.
1829. *Sphenopteris* Brongniart (*pars*), " Hist. des végét. foss.," p. 169.
1828. *Pecopteris* Brongniart (*pars*), " Prodrome," p. 54.
1833. *Pecopteris* Brongniart (*pars*), " Hist. des végét. foss.," p. 267.
Heteropteris Brongniart MS. (*non* Humboldt, Bonpland, and Kunth), Collection of the Muséum d'Hist. Nat., Paris.
1877. *Diplothmema* Stur (*pars*), " Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, pp. 120 (226), 127 (233).
1883. *Diplothmema* Stur (*pars*), " Morph. u. System. d. Culm-u. Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 183 (815).
1885. *Diplothmema* Stur (*pars*), " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 283.
1878. *Mariopteris* Zeiller, " Végétaux foss. du terrain houiller," *Expl. Carte géol. France*, vol. iv, p. 68.
1879. *Mariopteris* Zeiller, " Note sur le genre *Mariopteris*," *Bull. Soc. géol. France*, ser. 3, vol. vii, p. 93.
1888. *Mariopteris* Zeiller, " Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 195 [159].
1893. *Mariopteris* White (*pars*), " Flora of Outlying Carboniferous Basins of South-western Missouri," *Bull. U.S. Geol. Survey*, No. 98, p. 46.
1899. *Mariopteris* Potonié, " Lehrb. d. Pflanzenpal.," p. 140.

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* " Flora d. Vorwelt," pl. xiv, fig. 27, 1804; *Filicites pteridius* Schlotheim, " Petrefactenkunde," p. 406, 1820. See also ZEILLER, " Flore foss. bassin houil. de Commentry," p. 194, pl. xix, figs. 1–3, 1888.

1899. *Mariopteris* White, " Foss. Flora Lower Coal Measures of Missouri," *Monog. U.S. Geol. Survey*, vol. xxxvii, p. 30.
1900. *Mariopteris* Zeiller, " Éléments de Paléobotanique," p. 93.
1912. *Mariopteris* Huth, " Foss. Gattung *Mariopteris* in geol. u. botan. Beziehung," Inaugural-Dissertation (Berlin), p. 1.
1912. *Mariopteris* Huth in Potonié, " Abbild. u. Beschreib. foss. Pflanzen-Reste " (*K. preuss. geol. Landesanst.*), Lief. 8, No. 141.
1913. *Mariopteris* Gothan, " Oberschlesische Steinkohlenflora," Teil 1, *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft lxxv, p. 84.
1914. *Mariopteris* Bureau, " Bassin de la Basse Loire," fasc. 2, " Flores fossiles," *Études Gîtes Min. France*, p. 279.
1921. *Mariopteris* Gothan in Potonié, " Lehrb. d. Paläobot." (Zweite Auflage), p. 89.
1923. *Mariopteris* Gothan in Gürich, " Leitfossilien," Lief. 3, " Karbon u. Perm. Pflanzen," p. 40.
1879. *Pseudopecopteris* Lesquereux, " Atlas to the Coal Flora," p. 6.
1880. *Pseudopecopteris* Lesquereux, " Coal Flora," vol. i, p. 190.

Description.—Form-genus. Stem at least 2 cm. in breadth, but slender in proportion to its length, geniculate, longitudinally striated, and bearing numerous transversely-elongate small bar-like elevations. Fronds distant, spirally arranged on stem, rachis naked, 12 cm. or more in length, frequently longitudinally striated and usually bearing numerous short transversely-elongated elevations occasionally mixed with scattered apiculi, very rarely smooth or punctate, dichotomizing at apex at a very open angle, and dividing the frond into two equal segments. These two short primary arms are also naked and again divide, and of the resulting fork the posterior branch is shorter than the anterior one. The four axes into which the frond is thus divided form the rachises of the four primary pinnæ, which are usually bipinnate, but sometimes tripinnate, and more rarely quadripinnate.

Pinnules pecopteroid, sub-triangular, and attached by the whole width of their base, free or decurrent, and united to each other or more or less contracted at base, entire, lobed, or with margins undulated or bearing more or less prominent teeth. The basal pinnule on the posterior side is usually distinctly larger than the others and divided into two prominent lobes which may be entire or dentate.

Nervation immersed and frequently difficult to trace distinctly; the median vein extends to near the apex of the pinnule, the lateral veinlets depart at a more or less acute angle and are at least always once-divided, but frequently a second dichotomy occurs. When the pinnules are uncompressed the median and lateral veinlets are seen to lie in little furrows on the surface of the pinnule.

Fructification unknown.

Remarks.—The majority of the species included in the genus *Mariopteris* are imperfectly known, but they all possess a certain character in the branching and foliage that forms a distinct type of frond-structure. Of none of the species is the fructification known; if this were discovered it might probably show that more than one genus is included in *Mariopteris*, since vegetative characters cannot be relied on as an index of natural affinity. Though the genus *Mariopteris* is therefore only a " Form Genus," it serves a very useful purpose for the inclusion of a certain type of frond-structure, but it must be borne in mind that the real relationship of the species to each other is undetermined.

Of the various members of the genus, *Mariopteris nervosa* Brongniart sp. is that best known, and is by far the most common species.

At text-fig. 85 a diagrammatic representation of part of a plant of *Mariopteris* is given. This figure is founded on the fine specimen of *Mariopteris nervosa* Brongniart sp. described and figured by Zeiller.*

The geniculate stem is shown at x, x, which gives off four fronds, one of which is lettered A. The frond consists of a naked petiole A that bifurcates into two short arms at its apex B, B, which are also naked; that is, they bear no pinnules. These two arms (B, B) again dichotomize into branches C1, C1 and C2, C2, of which the lower (C2, C2) are shorter than the other two arms C1, C1. On these rachises are borne the foliage-bearing pinnæ E′, on some of which are represented the pinnules E″. One of the characteristics of the genus is the division of the posterior basal pinnule into two prominent lobes, represented diagrammatically at F. The frond, therefore, is first divided into two sections by the dichotomy of the petiole A, and these sections again divide into what are here regarded as four primary pinnæ. These primary pinnæ on *Mariopteris* are usually bipinnate, but sometimes tripinnate in their lower portion. In another species, *Mariopteris grandepinnata* Huth,† the primary pinnæ are quadripinnate.

Text-fig. 85.—Diagrammatic representation of a plant of *Mariopteris nervosa* Brongniart sp. Explanation in the text.

The build of the stem and frond of *Mariopteris* is therefore similar in essential features to that of *Diplotmema* Stur, for though in *Diplotmema* the arms of the dichotomy of the petiole do not again divide, the basal pinna on their posterior side, however, is frequently much more developed and larger than the succeeding pinnæ. This results in a ramification very similar in appearance to that seen in *Mariopteris*.

* "Flore foss. bassin houil. de Valenciennes," pl. xxiii.

† Huth in Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8 (1912), No. 156.

The genus *Mariopteris* differs from the genus *Diplotmema* in the foliage being pecopteroid. The pinnules, however, are very variable in form, even on the same specimen, and this is illustrated by the figures given here. This variation in the pinnules evidently depends not only on the position on the frond of the pinna that bears them, but also on the age of the individual from which the specimen has been derived, whether mature or otherwise.

Before passing from the description of the build of the plant of *Mariopteris* I should remark that Zeiller held a different view from that mentioned above. What is here described as the stem (in accordance with a view I believe to be held by others) was regarded by Zeiller as the main rachis of the frond, and what are here treated as fronds he believed to be primary pinnæ, which he described as placed alternately on the two sides of the rachis. That these lateral organs are attached to the axis spirally has been demonstrated by Stur, and their spiral arrangement is clearly seen on his figures.* Even on Zeiller's figure † one can see the spiral attachment of the petioles; and with the object of indicating this character I have slightly altered the figure given by Huth,‡ which is reproduced in our text-fig. 85. The spiral arrangement of the attached organs to their axis seems to me to show conclusively that the main axis of the *Mariopteris muricata* figured by Zeiller is a stem, and not a rachis of a frond, and that the attached organs are consequently fronds.

In further support of his view that the main axis of his specimen of *Mariopteris muricata* was the principal rachis of a frond and not a stem, Zeiller refers to the great variation found in the pinnules of different specimens of the plant. If the attached organs were fronds (he contends), then they all should show similarity in detail to each other, which different specimens of the plant do not. These variations he ascribes to such specimens being derived from pinnæ which held different levels on the frond; those which were situated on its upper region having more slightly segmented pinnules than those placed towards the centre or base of the frond. If this view is the correct explanation for the variation to which he refers in *Mariopteris* pinnules, then one must treat the stem as the main rachis of the frond, especially when in these various forms have been included what I believe to be four distinct species. This argument entirely overlooks an important factor in bringing about the variation to which he refers, for these fragments of fronds which show the variation in size and segmentation of the pinnules may in part be derived (and I believe were derived) from individuals of different ages and development, in which such variations would more naturally occur. Others of the "variations" arise through more than one species being brought together. That individual plants of *Mariopteris* of different ages and development existed side by side is beyond question; these would doubtless show as great variations in the form and size of their pinnæ and pinnules as those observable on specimens of some existing species of ferns.

* Stur, "Carbon-Flora d. Schatzlarer Schichten," p. 397, pl. xxii, figs. 1, 2.

† "Flore foss. bassin houil. de Valenciennes," pl. xxiii.

‡ Huth in Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8, No. 141, fig. 1.

The small specimen given on our Pl. CXLIV, fig. 4, I believe to be most probably a young and small frond of *Mariopteris nervosa* Brongniart sp., though one cannot be absolutely certain of this.

Another young frond, clearly belonging to *Mariopteris nervosa* Brongniart sp.,

TEXT-FIG. 86.—*Mariopteris nervosa* Brongniart sp. Foliar portion of a young frond. Natural size. Locality and horizon unknown. Dawes Collection, Museum, Victoria University, Manchester.

is given at text-fig. 86, natural size. The two arms of the dichotomy at the top of the petiole must have been very short, for the two segments into which the frond is divided are brought close together; but a second dichotomy must have taken place, as is shown by the presence of four primary pinnæ. These four primary pinnæ, however, are only pinnate, a common feature in the fronds of young fern plants, even when the fully developed fronds are bipinnate or tripinnate. To a certain extent, therefore, I am inclined to ascribe the variation seen in the form and segmentation of the pinnules on specimens of *Mariopteris* to the different ages of the individuals from which such specimens have been derived.

Probably all the species of *Mariopteris* were scramblers and supported themselves by resting on surrounding vegetation. The stem was too slender in proportion to its length to have supported itself in an upright position; and that it held a more or less upright position is shown by the spiral arrangement of its fronds; apparently it attained this position by means similar to those adopted by *Diplotmema adiantoides* Schlotheim sp. and allied species.*

There is good reason to believe that at least all those members of the genus *Mariopteris* on whose stems and petioles elongated transverse bars and longitudinal striations are to be seen, are Pteridosperms. These short bars were formerly supposed to mark the places from which scales had been removed, but it has been shown that they are sub-epidermal structures and comparable to the bars of sclerotic tissue in the cortex of *Heterangium*.† The longitudinal striations in the cortex of *Mariopteris* also appear to be similar to the sclerenchymatous strands in the cortex of the same genus.

These two structures are only known to occur in the cortex of Pteridosperms, and afford sufficient evidence, I think, for including in that group such species of *Mariopteris* as possess them.

The systematic position of the other species of *Mariopteris* whose stems or petioles do not exhibit these characters must be left an open question for the present.

Distribution.—In Britain, the genus has been found only in the Upper Carboniferous, but occurs in the Lanarkian, Westphalian, Staffordian, and Radstockian Series. It is more common, however, in the Lanarkian and Westphalian than in the two higher Series.

Mariopteris muricata Schlotheim sp.

Plate CXXXVIII, figs. 1, 1*a*, 2; Plate CXLIV, fig. 3; Plate CXLV, figs. 1–11; text-fig. 87.

1804. Schlotheim, "Flora d. Vorwelt," pp. 54, 55, pl. xii, figs. 21 and 23.
1820. *Filicites muricatus* Schlotheim, "Petrefactenkunde," p. 409.
1834. *Filicites muricatus* Schlotheim, "Verstein. aus v. Schlotheim's Sammlung," Kupfertafeln, Heft 1, p. 8, pl. xii, figs. 21 and 23.
1826. *Pecopteris muricata* Sternberg, "Essai flore monde prim.," vol. i, fasc. 4, p. xviii.
1836. *Pecopteris muricata* Brongniart (*pars*), "Hist. des végét. foss.," vol. i, p. 352, pl. xcv, figs. 3, 4 (*non* pl. xcvii).
1848. *Pecopteris muricata* Sauveur (*pars*), "Végét. foss. du terr. houil. Belgique," pl. xliv, fig. 2 (*Nouv. Mém. Acad. Roy., Brussels*).

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* See *ante*, p. 245.

† Gothan, "Methoden und neue Erfolge bei der Untersuchung kohlig-erhaltener Pflanzenreste," *Sitzungsber. Gesellsch. Naturforsch. Freunde, Berlin*, Jahrgang 1915, No. 2, p. 45, pl. ii, figs. 2, 2*a*.

1869. *Pecopteris muricata* Schimper, " Traité de paléont. végét.," vol. i, p. 54. (*Refs. in part.*)
1836. *Alethopteris muricata* Göppert, " Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 313.
1854. *Alethopteris muricata* Ettingshausen, " Steinkohlf. v. Radnitz," *Abhandl. k. k. geol. Reichsanst.*, Band ii, Abth. 3, p. 43, pl. xiv, fig. 1.
1876. *Sphenopteris muricata* Feistmantel, " Verstein. d. Böhm. Ablager.," p. 281, pl. lxv, fig. 3 (excl. syn. *Sph. acutifolia*).
1877. *Diplothmema muricatum* Stur, " Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 230.
1883. *Diplothmema muricatum* Stur, " Morph. u. Syst. d. Culm-und Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 194.
1885. *Diplothmema muricatum* Stur (*pars*), " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 6, p. 393, pl. xxi, figs. 2, 3; pl. xxii, figs. 1, 2; pl. xxiii, figs. 1 (2–3 ?), 4–6. (*Refs. in part.*)
1879. *Mariopteris muricata* Zeiller, " Note sur le genre *Mariopteris*," *Bull. Soc. géol. France*, ser. 3, vol. vii, p. 93.
1899. *Mariopteris muricata* Zeiller, " Flore foss. bassin houil. d'Héraclée," *Mém. Soc. géol. France*, xxi, p. 32, pl. ii, figs. 14, 15. (*Ref. in part.*)
1899. *Mariopteris muricata* Hofmann and Ryba (*pars*), " Leitpflanzen," p. 44, pl. vi, fig. 16.
1899. Cf. *Mariopteris muricata* Frech, " Lethaea geogn.," Teil 1; " Lethaea palaeoz.," Band ii, Lief. 2, pl. 50*a*, fig. 5.
1904. Cf. *Mariopteris muricata* Arber, " Foss. Flora of Culm Measures," *Phil. Trans.*, Ser. B, vol. cxcvii, p. 305, pl. xx, fig. 17.
1913. *Mariopteris muricata* Gothan (*pars*), " Oberschlesische Steinkohlenflora," Teil 1, *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft lxxv, p. 92, pl. xviii, text-fig. 7 (p. 89). (*Refs. in part.*)
1913. Cf. *Mariopteris muricata* Huth (*pars*), " Epidermis von *Mariopteris muricata*," *Zeitschr. deutsch. geol. Gesellsch.*, Band lxv, p. 143, figs. 1, 3, 4.
1915. *Mariopteris muricata* Gothan, *Sitzungsb. Gesellsch. Naturforsch. Freunde, Berlin*, Jahrgang 1915, No. 2, p. 47, pl. ii, figs. 2, 2*a* (*Epidermis*).
1879. Cf. *Pseudopecopteris muricata* Lesquereux, " Coal Flora," vol. i, p. 203, pl. xxxvii, fig. 2.
1826. *Pecopteris incisa* Sternberg, " Essai flore monde prim.," vol. i, fasc. 4, p. xx; vol. ii, fasc. 5–6, pl. xxii, fig. 3; fasc. 7–8, p. 156.
1834. *Pecopteris laciniata* Lindley and Hutton, " Fossil Flora," vol. ii, pl. cxxii.
1877. Cf. *Pecopteris laciniata* Lebour, " Illustr. of Fossil Plants," p. 59, pl. xxix.
1877. Cf. *Sphenopteris macilenta* var. Lebour (*non* L. and H.), *ibid.*, p. 39, pl. xix.
1877. Neuropteroid frond, Lebour, *ibid.*, p. 31, pl. xv.
1885. *Diplothmema acutum* Stur (*pars*) (*non* Brongniart), " Carbon-Flora d. Schatzlarer Schichten " (*loc. cit.*), p. 365, pl. xxvi, fig. 4.
1886. *Mariopteris acuta* Zeiller (*non* Brongniart), " Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 164, pl. xviii, fig. 2.

Description.—Stem attaining a breadth of 1·5 cm. or more, but slender in proportion to its length, longitudinally striated and bearing short, transversely-elongated bars. Fronds spirally placed on stem, of moderate size, petiole 12 cm. or more in length and 4 mm. or more in breadth, occasionally showing longitudinal striations and almost invariably bearing numerous short transversely-elongated bars, dichotomizing at its apex at an open angle into two naked branches which attain a length of about 0·2 cm. These two arms again dichotomize at an open angle, the superior branch being longer than the inferior one. These four resulting axes form the rachises of the four primary pinnæ of the frond. Primary pinnæ narrow-deltoid, tripinnate or quadripinnate.

Secondary pinnæ alternate, broadly lanceolate, rachis straight or slightly flexuous and occasionally extended beyond the pinnules in the form of a spine-like prolongation.

Tertiary pinnæ slightly oblique to rachis, alternate, lanceolate or linear-lanceolate, free or touching laterally, rachis straight and when well preserved exhibiting short transverse bars ; the upper-situated tertiary pinnæ frequently (or always ?) terminate in a spine-like projection of the rachis.

Pinnules alternate, slightly oblique to rachis, free or decurrent, and the uppermost more or less united to each other.

Both lower and upper surface bear many capitate glandular hairs. On lower-situated tertiary pinnæ the pinnules are free, of an oval contour, with three or four saw-like teeth on each margin and a terminal lobe with two or three small sharp teeth, the basal pinnules on both sides of the rachis are contracted at base and attached by a short footstalk, with a large lateral lobe on its distal margin which may be entire or have a few small marginal teeth. As the pinnules are followed upwards they become attached by an increasingly broader base till they are united to the rachis by the whole of their slightly decurrent base, but remain free till the extreme apex is reached. Terminal lobe small and having two to three small sharp teeth. On the uppermost tertiary pinnæ the pinnules are smaller, decurrent, and slightly united to each other, and the rachis is prolonged as a spine-like point.

Nervation immersed, and frequently the complete course of the veinlets is difficult to trace. The median decurrent vein extends almost to the apex of the pinnule, where it divides into two veinlets ; the lateral veinlets depart from the median vein at an acute angle, are always once divided, but of the two arms, one frequently again dichotomizes. A few veinlets occasionally appear to enter the pinnules direct from the rachis, but in reality are derived from the median vein.

Fructification unknown.

Remarks.—The great majority of palæobotanists have united *Pecopteris nervosa* Brongniart, *Pecopteris Sauveuri* Brongniart, and *Diplotmema* (*Mariopteris*) *hirtum* Stur with *Mariopteris muricata* Schlotheim sp. At one time I held this view myself, but since I have had the opportunity of examining a large and well-preserved series of specimens of these plants, I believe that the three species mentioned above, though they may be close allies, form individual species. When one has only fragmentary or imperfectly-preserved specimens under review it may be difficult to separate them, but I believe there is no difficulty if well-preserved material is available for examination. In such a difficult genus as *Mariopteris,* containing many allied species, well-preserved material is essential for a satisfactory determination of the species. Fragmentary specimens, even if well-preserved, are sometimes useless for a critical determination.

Of the many figures of *Mariopteris muricata* given in works dealing with the Carboniferous Flora, very few have illustrated the form of the plant quite similar to that on which SCHLOTHEIM founded his species. It is given by BRONGNIART on pl. xcv, fig. 3, of his "Hist. des végétaux fossiles." STUR also figures SCHLOTHEIM'S form of the species in the "Farne der Carbon-Flora der Schatzlarer Schichten," pl. xxiii, fig. 4. Those given by ZEILLER as *Mariopteris muricata* forma *typica* should be ascribed to *Mariopteris nervosa* Brongniart sp. To make this point clear, I reproduce at text-fig. 87 a copy of the more perfect specimen of SCHLOTHEIM'S types.

TEXT-FIG. 87.—*Mariopteris muricata* Schlotheim sp. Copy of the original figure given by SCHLOTHEIM in the "Flora d. Vorwelt" (pl. xii, fig. 23). Natural size.

In his description of *Mariopteris muricata*, BRONGNIART distinguishes two varieties: var. α with the rachis bearing short elongated bars, and var. β with a smooth rachis. On the smaller rachises the bars are usually not observable, and when present are few in number, smaller, and more distantly placed. When not observable their absence may be due to conditions of preservation, since they are sometimes not shown even on the petioles and larger rachises of the frond, where they are known to exist.

In working out the synonymy of *Mariopteris muricata* Schlotheim sp. it is often very difficult to determine the species to which some of these figures should be referred, whether to *Mariopteris muricata, Mariopteris nervosa,* or to *Mariopteris Sauveuri,* as some of the figured specimens have been fragmentary, and the figures themselves are not always very satisfactory.

An attempt has been made here to separate these and place them under one or other of the four species which have been so frequently placed under *Mariopteris muricata.* I scarcely venture to think that I have been quite successful in this attempt, for some of the figures dealt with are far from being satisfactory for such an undertaking; however, if under *Mariopteris muricata* four distinct species have been included (as I believe there have), some such attempt is necessary.

A specimen from near the top of the Westphalian Series, which agrees absolutely with the more perfect of Schlotheim's two figures, is given natural size on Pl. CXXXVIII, fig. 1; part of a pinna from this is enlarged two times at fig. 1*a*. The specimen shows a portion of two pinnæ which are possibly fragments of two secondary pinnæ of a quadripinnate frond, as their parallel position to each other rather suggests. A flexuous band, representing the vascular bundle, passes up the middle of the main rachises of the two pinnæ and gives off strands to the alternate lateral tertiary pinnæ. These latter are lanceolate and bear alternate pinnules. The pinnules have an oval contour and the lower-placed ones have a contracted base. In the case of the anterior and posterior basal pinnule, this contraction extends so far that they become pedicellate. The pinnules are free, slightly oblique to the rachis, and, with the exception of the basal pinnule on each side of the rachis, usually have three sharp-pointed, saw-like teeth on each margin. Sometimes the teeth appear as obtuse or rounded, but this appearance seems to be mostly due to the apex being embedded in the rock or broken off, though it may in a few cases be a natural feature. On this example, the basal pinnule on both sides of the rachis shows the development of a large lateral lobe on its distal margin, which, as well as the other portion of the pinnule, has a few small teeth (fig. 1*a*).

As the pinnules are traced from the base to the apex of the pinnæ they become gradually less contracted below, and are attached to the rachis by an increasingly wide base. At the same time they become slightly decurrent and the basal contraction eventually entirely disappears. They remain free until the extreme apex of the pinna is reached, where they are slightly united. The lower pinnæ end in a small terminal lobe, with one or two sharp-pointed teeth.

On the uppermost tertiary pinnæ the pinnules are less contracted at base and become slightly united to each other, and the pinnæ sometimes end in a spine-like prolongation of the rachis.

The nervation is not very distinctly exhibited on this specimen, but indications of it can be observed in the enlargement at fig. 1*a*. It will be described later from another specimen.

Part of another example of the typical form of *Mariopteris muricata*, from the base of the Lanarkian Series, is given on Pl. CXLIV, fig. 3, natural size. The form and attachment of the pinnules are here similar to those of the specimen described above, and the figure is added chiefly to show the distribution of the type-form of the species, which is rare in Britain and appears to be also rare on the Continent.

The specimen given on Pl. CXXXVIII, fig. 2, probably shows the termination of a secondary pinnæ. The pinnules on the lower lateral pinnæ have the characteristic lateral lobes, but are not so prominent as on fig. 1 of the same plate. The lateral pinnæ as traced upwards also become broader in proportion to their length, and in the upper ones the rachis is prolonged beyond the pinnules as a spine-like point. The apex of the secondary pinna also terminates in some spine-like projections. These spine-like projections of the rachises are not clearly exhibited on the figure, but are quite distinctly seen on the specimen.

Through the great kindness of Mr John Walton, of Manchester University, who has placed in my hands some excellent specimens of the pinnules of *Mariopteris muricata*, I am able to describe some interesting features in their structure and the arrangement and origin of the nervation.

The specimens were discovered in a small piece of shale collected by the Rev. R. H. Goode, and were preserved in a mummified condition. They required no further treatment than to be freed from the matrix and mounted for microscopical examination.

Some pinnules holding different relative positions on the pinnæ are shown on Pl. CXLV, figs. 1–3. That seen at fig. 1, which is enlarged six and a half times, was situated towards the lower end of a pinna holding a place towards the base of a primary pinna. It bears six alternate teeth or lobes with recurved margins, three on each side, which end in an obtuse or more or less sharp point. On this example the apex of the pinnule is broken off. At the base of the figure the vascular strand of the rachis gives off a lateral vein which enters the pinnule obliquely. Before this median vein enters the pinnule proper, it gives off a lateral veinlet which passes into the distal basal lobe and dichotomizes three times in its course to the margin of the pinnule. In an ordinary incrustation, owing to the opacity of the rachis, not only the median vein but the veinlet passing into the distal basal lobe would appear as being derived directly from the vascular strand of the rachis. In reality, however, only the median vein has such an origin.

This is also seen at fig. 2, where the pinnule has held a higher position on the pinna than that given at fig. 1. In an incrustation-specimen, the branches of the veinlet passing into the distal basal lobe would also appear here as if they were given off from the rachis of the pinnæ, but are seen to spring from the median vein. It is therefore most probable, if not even certain, that in the pinnules of all the species of *Mariopteris* the lateral veinlets are all derived from the median vein and none enter the pinnule direct from the vascular strand of the rachis, as formerly supposed.

The flexuous median vein is decurrent or enters the pinnule obliquely from the rachis and extends to near the apex of the pinnule. To each lobe or tooth is given off a lateral veinlet which generally divides three times, and the veinlets go off in a somewhat unilateral manner to the outer margin of the pinnule. In the higher-placed smaller pinnules, which are becoming slightly united to each other, the lateral veinlets going to each lobe are divided only twice, except in the two basal lobes, where they may be divided three times. This is seen at fig. 2. The apex of this pinnule is perfect and shows the median vein to divide into two arms a short distance below the summit. These two arms again divide, and one of the resulting arms passes into the pointed apex of the pinnule, where it bears a stellate glandular structure at *a*. The dark line at *b*, which looks like a branch coming from the basal lateral veinlet, is a fold in the epidermis and has no connexion with the vascular system of the pinnule. In the specimen given at fig. 3, which is enlarged nine times, the lateral veinlets have not so distinct a unilateral arrangement as in the lobes of large pinnules such as that shown at fig. 1, and the sinuous vascular strand passing up this specimen is thicker than the median vein of a pinnule. I therefore conclude that the specimen shows the termination of a pinna with confluent pinnules which terminate in a sharp point.

The cuticle of the lower surface of a pinnule is enlarged sixty times at fig. 4. The cells in outline are usually two or three times longer than broad, but vary much in the proportion of length to breadth and are somewhat irregularly placed in their relation to each other. The stomata are badly preserved and their presence is only indicated by a few brown-coloured cells which probably correspond in position to the cells which surround the stomatal depression on the epidermis of *Mariopteris nervosa* Brongniart sp.* The guard-cells of the stoma have not been distinctly observed. On this specimen, although the outline of the epidermal cells is well shown, the small glandular hairs are very imperfectly preserved, and only occasionally can one observe their remains.

The outline of the cells of the upper epidermis is shown at fig. 5, enlarged sixty times. In the region of the median vein they are considerably elongated, being generally several times longer than broad, though they vary in length, but are of a fairly uniform width. In the areas between the veinlets they are somewhat smaller and more irregularly placed in relation to each other. They are in fact very similar in their arrangement to those of the under surface. The glandular hairs seem to be restricted to the neighbourhood of the median vein and veinlets. No stomata were observed.

A small portion of a pinnule, including a sinus between two teeth, is given at fig. 6, enlarged fifty times. The marginal structure of the pinnule has a net-like appearance and is formed apparently of a meshwork of small square or rhomboidal cells; it is sharply defined from the inner-lying epidermal cells except at the base of the sinus, where they gradually merge with the cells of the epidermis. At the base of the pinnule they also gradually pass into the cells of the margin of the rachis, which

* *Cf.* Pl. CLIII, fig. 5.

does not possess any of the small, square, or rhomboidal areas, but only elongated cells similar to those seen at fig. 5 in close proximity to the vein. A small portion of this net-like structure is enlarged a hundred and five times at fig. 7. The margin also bears small capillate glandular hairs, which are seen in profile projecting from its margin on fig. 2.

The marginal band with its net-like structure seems to hold a direct relation to the recurving of the margin of the pinnule, for it is only on those parts of the pinnules where they occur that the margin is recurved. This appearance of small rhomboidal cells is certainly due to the crossing of one set of epidermal cell-outlines over another; the one set being brought above the other by the overfold of the margin.

The glandular hairs are much larger on the epidermis covering the principal veinlets and median vein and especially on the covering of the vascular strand of the rachis and its immediate neighbourhood. The stalk of a large hair is seen at *a*, fig. 1, and beside it are the bases of some smaller hairs.

A small fragment of the epidermis, probably from a rachis, is given at fig. 8, enlarged thirty times. It bears the bases of many large hairs, from all of which the secreting head has been removed. This is the usual condition in which they occur on our specimen. The basal portion seems to be formed of from eight to twelve elongated cells, which show no trace of transverse septa.

A few complete hairs have been preserved, however, and two of these are shown at figs. 9 and 10, enlarged one hundred and five times. In that shown at fig. 9, the cells forming the upright column are not very clearly defined. The head shows no definite structure, but appears to have been coated with a sticky substance to the surface of which a few minute microspores are adhering.

The most perfect hair observed is given at fig. 10, which exhibits its complete form. The base is much expanded (as is invariably the case) and the column appears to be formed of about twelve elongated, non-septate cells. At the base of the head are a few obscure remains, but no definite structure can be made out. The head itself appears as if formed of a structureless gelatinous mass. There is no doubt it was a secreting organ, as is shown by the foreign bodies found attached to it, as well as by its general appearance.

At the termination of the pinnules, and apparently connected with the extremity of the median vein, a very curious organ occurs. One of these terminating a pinnule is seen enlarged fourteen times at fig. 11, and under a smaller magnification at *a* on fig. 2. Their form appears to be that of a disc-like body which bears, projecting from its circumference, from six to eight small structures which give it the appearance of a rayed star. All these projections are evidently imperfect and have lost their upper portion. They are very opaque, but in two cases it has been possible to observe the structure of their remaining basal portion, and this seems to be formed of elongated cells quite similar to those of the glandular hairs. It would appear, then, highly probable that these terminal structures are formed of a few glandular hairs, which performed a secreting function. What function these secreting hairs fulfilled in the economy of the plant is a problem I am unable to solve.

With *Mariopteris muricata* Schlotheim sp. I unite *Mariopteris acuta* Zeiller (*loc. cit.*). The form of the pinnules and the whole character of his specimen, as shown on his fig. 2, are so similar to SCHLOTHEIM's figure that I do not see how it can be specifically separated. It is true that his enlargements of two pinnules show the lateral teeth to have sharp points, but so have some on SCHLOTHEIM's figures. They are also more spreading than BRONGNIART's enlarged pinnule of *Mariopteris* (*Sphenopteris*) *acuta*.

Mariopteris nervosa Brongniart sp. is distinguished from *Mariopteris muricata* by the more or less triangular or sub-triangular form of the decurrent pinnules, by their being almost invariably united to a greater or less extent, and (except the posterior basal pinnule and sometimes the corresponding pinnule on the anterior side) by their seldom having any lateral lobes. Even in the two varieties, *macrophylla* and *microphylla*, where the pinnules are more or less obtuse and united to each other for about half their length, their sub-triangular form is still preserved. The pinnules are also not contracted at the base except in the case of the posterior and anterior basal pinnules, which are usually slightly constricted.

Mariopteris Sauveuri is easily separated from *Mariopteris muricata* by its very obtuse pinnules with entire margins.

The species with which *Mariopteris muricata* is most likely to be mistaken is the *Mariopteris acuta* Brongniart sp., but the distinctive characters of these two plants will be discussed when describing the latter species.

The plant recorded under the name of *Mariopteris muricata* in my various papers dealing with the flora of the Coal Measures now proves to be almost invariably *Mariopteris nervosa* Brongniart sp.

Distribution.—Though *Mariopteris muricata* Schlotheim sp. may be more widely distributed in Britain than is shown by the undernoted list of localities, it is by no means a common species. It has been recorded from both the Westphalian Series and the Lanarkian Series.

WESTPHALIAN SERIES.

LANCASHIRE COALFIELD.

Horizon: Roof of Peacock Coal. *Locality:* Bardsley Colliery, Ashton-under-Lyne (G. WILD).

NORTH DERBYSHIRE AND NOTTINGHAM COALFIELD.

Horizon: Top Hard Coal. *Locality:* Warsop Main Colliery, 5 miles north-east of Mansfield (Rev. R. H. GOODE).

NORTHUMBERLAND AND DURHAM COALFIELD.

Horizon: Crow Coal. *Locality:* Phœnix Brickworks, Crawcrook, Ryton, County of Durham (W. ELTRINGHAM).

SOUTH WALES COALFIELD.

Horizon: Roof of Abergorky Coal. *Locality:* Upper Cymmer Pit, Porth, Glamorganshire (W. THOMAS).

Horizon: Pentre Seam. *Locality:* Trane Colliery, Gilfach Goch, Glamorganshire (D. DAVIES).

LANARKIAN SERIES.

CLACKMANNAN COALFIELD.

Horizon: ?. *Locality:* Crophead Pit, Sauchie, $1\frac{3}{4}$ miles north of Alloa.

MIDLOTHIAN COALFIELD.

Horizon: Diamond or Splint Seam. *Locality:* Whitehill Pit, Rosewell (Collection of Geological Survey, Edinburgh).

Mariopteris nervosa Brongniart sp.

Plate CXXXVIII, figs. 3, 4; Plate CXL, fig. 1; Plate CXLIII, figs. 1, 2; Plate CXLIV, figs. 1, 4–6; Plate CLIII, figs. 1–7; text-figs. 88 and 89.

1720. *Trichomanes minerale foliis integris mucronatis* Volkmann, "Silesia subterranea," Theil 1, p. 112, pl. xv, fig. 1.
1833. *Pecopteris nervosa* Brongniart, "Hist. des végét. foss.," vol. i, p. 297, pl. xciv; pl. xcv, figs. 1, 2.
1833. *Pecopteris nervosa* Lindley and Hutton, "Fossil Flora," vol. ii, pl. xciv.
1848. *Pecopteris nervosa* Sauveur, "Végét. foss. du terr. houil. Belgique," pl. xliv, fig. 1 (*Nouv. Mém. Acad. Roy., Brussels*).
1869. *Pecopteris nervosa* Schimper, "Traité de paléont. végét.," vol. i, p. 513. (*Refs. in part.*)
1873. *Pecopteris nervosa* Breton, "Étude géol. du sud de la Concession de Dourges," p. 411, pl. v, fig. 1. (Lille.)
1876. *Pecopteris nervosa* Heer, "Flora Foss. Helv.," Lief. 1, p. 33, pl. xv, figs. 1, 2.
1882. *Pecopteris nervosa* Weiss, "Aus der Flora der Steinkohlenformation" (*K. preuss. geol. Landesanst.*), p. 17, pl. xvi, fig. 98. (Zweiter Abdr.)
1882. *Pecopteris nervosa* Achepohl, "Niederrheinisch-Westfälische Steinkohlengebirge," pp. 74, 76, 90, pl. xxii, fig. 6; pl. xxiii, fig. 14; pl. xxviii, fig. 10.
1879. *Mariopteris nervosa* Zeiller, "Note sur le genre *Mariopteris*," *Bull. Soc. géol. France*, ser. 3, vol. vii, p. 97, pl. v, figs. 1, 2.
1880. *Mariopteris nervosa* Zeiller, "Végét. foss. du terr. houil.," *Expl. Carte géol. France*, vol. iv, p. 69, pl. clxvii, figs. 1, 2. (*Refs. in part.*)
1899. *Mariopteris nervosa* Hofmann and Ryba, "Leitpflanzen," p. 44, pl. vii, fig. 7.
1886. *Mariopteris muricata* forma *nervosa* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 173, pl. xx, fig. 1; pl. xxii, fig. 2; pl. xxiii, fig. 1.
1909. *Mariopteris muricata* forma *nervosa* Arber, "Fossil Plants of Kent Coalfield," *Quart. Journ. Geol. Soc.*, vol. lxv, p. 28, pl. i, fig. 6.
1836. *Alethopteris nervosa* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 312.
1855. *Alethopteris nervosa* Geinitz, "Verstein. d. Steinkf. in Sachsen," p. 30, pl. xxxiii, figs. 2, 3.
1869. *Alethopteris nervosa* Roehl (*non* Brongniart), "Foss. Flora d. Steink. Form. Westph.," *Palaeontographica*, Band xviii, p. 27, pl. xxxi, fig. 7.

1881. *Alethopteris nervosa* Achepohl, " Niederrhein. Westfäl. Steink. Form.," pp. 57 and 64, pl. xvi, fig. 1; pl. xviii, figs. 15, 16.
1877. *Diplothmema nervosum* Stur, " Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 124 (230).
1885. *Diplothmema nervosum* Stur, " Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 384, pl. xxiv, fig. 1; pl. xxv*b*, fig. 2.
1888. *Diplothmema nervosum* Toula, " Die Steinkohlen," p. 188, pl. i, figs. 12, 13.
1879. *Pseudopecopteris nervosa* Lesquereux, " Coal Flora," vol. i, p. 197, pl. xxxiv, figs. 1–3.
1876. *Pecopteris muricata* Heer, " Flora foss. Helv.," Lief. 1, p. 33, pl. xv, fig. 3.
1880. *Mariopteris muricata* Zeiller, " Véget. foss. du terr. houil.," *Expl. Carte géol. France*, vol. iv, p. 71, pl. clxvii, fig. 5.
1886. *Mariopteris muricata* Zeiller (*pars*), " Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 173, pl. xx, figs. 1–3; pl. xxi, fig. 1; pl. xxii, figs. 1, 2; pl. xxiii, fig. 1. (*Refs. in part.*)
1899. *Mariopteris muricata* Potonié, " Lehrb. d. Pflanzenpal.," p. 140, fig. 135.
1899. *Mariopteris muricata* Hofmann and Ryba (*pars*), " Leitpflanzen," p. 44, pl. vi, fig. 5.
1907. *Mariopteris muricata* Zalessky (? *pars*), " Flore Foss. Terr. houill. du Donetz," I, *Bull. Comité géol. Russie*, vol. xxvi, p. 388, pl. xiii, fig. 20 (? fig. 19) (*non* pl. xiv, figs. 6, 6*a*).
1910. *Mariopteris muricata* Renier, " Documents pour l'étude de la paléont. du terr. houil.," pl. lxxxiv.
1912. *Mariopteris muricata* Huth in POTONIÉ, "Abbild. u. Beschreib. foss. Pflanzen-Reste" (*K. preuss. geol. Landesanst.*), Lief. 8, No. 143, figs. 2–5 (*non* fig. 1).
1912. *Mariopteris muricata* Arber, " Fossil Plants Forest of Dean," *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 3, p. 331, pl. xxxvii, fig. 1.
1912. *Mariopteris muricata* Huth, " Foss. Gattung *Mariopteris*," Inaugural-Dissert. (Berlin), p. 37, figs. 9–13 (*non* fig. 8).
1913. *Mariopteris muricata* Gothan (*pars*), " Oberschlesische Steinkohlenflora," Teil I, *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft lxxv, p. 92, pl. xxi, fig. 4. (*Refs. in part.*)
1921. *Mariopteris muricata* Gothan in POTONIÉ " Lehrb. d. Palaeobotanik" (Zweite Auflage), p. 89, fig. 80.
1923. *Mariopteris muricata* Gothan in GÜRICH, " Leitfossilien," Lief. 3, p. 40 (? pl. xix, fig. 2), text-figs. 33, 34.
1923. *Mariopteris* cf. *muricata* Walton, *Ann. of Bot.*, vol. xxxvii, p. 384, pl. ix, figs. 2–6.
1869. *Alethopteris muricata* Roehl, " Foss. Flora d. Steink.-Form. Westphalens," p. 78, pl. xi, fig. 1.
1885. *Diplothmema muricatum* Stur (*pars*), " Carbon-Flora d. Schatzlarer Schichten, *Abhandl. k. k. geol. Reichsanstalt*, Band xi, Abth. 1, p. 393, pl. xxi, figs. 1, 4, 5; pl. xxii, figs. 3–5; pl. xxiii, figs. 1–3, 5, 6.
1838. *Alethopteris Lindleyana* Presl in STERNBERG, " Versuch," vol. i, fasc. vii-viii, p. 145.
1854. *Sphenopteris acutifolia* Ettingshausen (*non* Brongniart), " Steinkf. v. Radnitz," *Abhandl. k. k. geol. Reichsanst.*, Band ii, Abth. 3, p. 39, pl. xiv, fig. 2. (*Ref. in part.*)
1862. *Pecopteris subnervosa* Roemer, " Beiträge zur geol. Kenntniss d. nordwest. Harzgebirges," *Palaeontographica*, Band ix, p. 36, pl. viii, fig. 11.
1869. *Pecopteris subnervosa* Roehl, " Foss. Flora d. Steink.-Form. Westphalens," p. 90, pl. xiii, fig. 5.
1869. *Pecopteris subnervosa* Schimper, " Traité de paléont. végét.," vol. i, p. 513.
1877. Cf. *Sphenopteris latifolia* var. Lebour (*non* Brongniart), " Illustrations of Fossil Plants," p. 63, pl. xxxi.
1877. *Neuropteris heterophylla* Lebour (*non* Brongniart), *ibid.*, p. 29, pl. xiv.
1877. *Pecopteris* (*Alethopteris*) *aquilina* Lebour (*non* Schlotheim), *ibid.*, p. 33, pl. xvi.
1877. Cf. *Pecopteris* (*Alethopteris*) *marginata* Lebour (*non* Brongniart), *ibid.*, p. 35, pl. xvii.
1877. *Pecopteris* (*Alethopteris*) *serra* ? Lebour (*non* Lindley and Hutton), *ibid.*, p. 45, pl. xxii.
1882. *Odontopteris* Achepohl, " Niederrheinisch-Westfälische Steinkohlengebirge," pp. 93, 95, pl. xxxi, fig. 2; pl. xxxii, figs. 4, 5.

1882. *Odontopteris dentiformis* Achepohl, *ibid.*, p. 93, pl. xxxi, figs. 6, 6*a*.
1882. *Odontopteris Reichiana* Achepohl (*non* Gutbier), *ibid.*, p. 95, pl. xxxii, figs. 6, 9.
1883. *Alethopteris conferta* Achepohl (*non* Sternb.), *ibid.*, p. 117, pl. xxv, fig. 10.
1883. *Alethopteris acuta* Achepohl, *ibid.*, p. 118, pl. xxxvi, fig. 6.

Description.—Petiole dividing at apex into two naked arms which attain a length of 4 cm. or more. Each arm again dichotomizes at an open angle, and the resulting four axes form the rachises of the four primary pinnæ of which the frond is composed. Primary pinnæ broadly lanceolate ; rachis straight or slightly flexuous, sometimes with one or with two ridges passing up the middle, very finely striated longitudinally and bearing irregularly-placed, short, transversely-elongated bars on its outer surface. Secondary pinnæ slightly oblique to rachis, alternate, lanceolate or linear-lanceolate, those at the base of the pinna within the fork shorter than those on the outer side ; rachis straight. Tertiary pinnæ alternate, lanceolate, more or less oblique to rachis.

Pinnules sub-triangular in form, sides slightly convex or straight, within curved margins, decurrent, almost invariably united to each other, sometimes free at the base of the pinnæ, apex acute or blunt and rounded. The basal posterior pinnule and (more rarely) the basal anterior pinnule have a prominent lobe on the distal margin, other pinnules usually entire, though rarely they may have one or more feebly-developed lobes on their distal margin. The upper and lower surfaces of the pinnules are studded with capitate glandular hairs and their lower surface bears many stomata. When the foliage-bearing pinnæ are followed upwards, the pinnules become more and more united to each other until they finally assume the form of elongated pinnules.

Nervation immersed. Median vein in the basal posterior pinnule straight, in the upper-situated pinnules it gradually becomes more and more decurrent and extends to near the apex of the pinnule, where it divides into two arms. The lateral veinlets depart at an acute angle and take a straight upward course to the margin of the pinnule. They dichotomize near their base, and in the basal portion of the pinnule one of the arms frequently again divides. The nervation, however, is seldom distinctly shown and is difficult to observe in detail.

Remarks.—Though *Mariopteris nervosa* Brongniart sp. is very common in the Lanarkian Series and Westphalian Series, I have not met with any specimen, showing the frond at all approaching completeness, which one could regard as that of an individual which had attained maturity.

The best example is that given on Pl. CLIII, fig. 7, which shows a dichotomy of one of the two arms of the petiole, but one of the two resulting primary pinnæ is broken off. The portion of a primary pinna seen at the margin of the specimen may be the missing part, but it lies at a lower level in the matrix. All the secondary pinnæ are pinnate except the basal one, which has a few small tertiary pinnæ on its posterior margin. The pinna within the fork at the base of the primary pinna is much shorter than that on the opposite side of the rachis. The alternate sub-triangular pinnules are united to each other except on the lowest pinna, where they are assuming the form of pinnæ. This specimen has not the advanced state of division of the frond seen in many specimens, and it may have been derived from a plant of immature growth.

At text-fig. 86, the complete foliar portion of a frond of *Mariopteris nervosa* is given natural size. This bears all the appearance of being the frond of a young plant of the species. Each of the four primary pinnæ is only pinnate and the pinnules are elongated and of large size. The arms of the primary dichotomy at the apex of the petiole must have been very short, as the two sections into which the frond is divided are brought very close together.

In the early growth-stages of many species of existing ferns (with which, in the development of their vegetative organs, Pteridosperms may I think be compared) a similar course of frond-development can be observed. In such species pinnate fronds are first produced, but when they reach a more mature age, they bear bipinnate fronds, of larger size, but with smaller pinnules. This is well seen in the common Prickley Shield Fern (*Polystichum aculeatum*) and doubtless in many others.

An exceedingly small frond, which I refer to *Mariopteris nervosa,* is seen natural size at fig. 4, Pl. CXLIV, and enlarged two times at fig. 4*a*. It shows the foliar portion of the frond, but the petiole is not preserved. The two upper primary pinnæ are each only about 2·5 cm. in length and the lower pair are about 1·25 cm. in length. They are simply pinnate, and the secondary pinnæ are here represented by a pinnule-like structure of which the lower only shows a slight lobe on the distal margin.

The three fronds of *Mariopteris nervosa* described above show a progressive series of ages and give an interesting glimpse of frond-development in Carboniferous times.

Brongniart distinguished three varieties of his *Pecopteris* [*Mariopteris*] *nervosa*:

Var. α, *macrophylla*: pinnules ovate, contiguous, terminal pinnule ovate-acute.

Var. β, *microphylla*: pinnules ovate, sub-contiguous, terminal pinnule linear-lanceolate.

Var. γ, *oblongata*: pinnules oblong, with dilated base, distant, terminal pinnule smaller, ovate-oblong.

These different varieties or forms merge into one another, and a definite line between them cannot be drawn; but an attempt has been made to illustrate them so far as our specimens permit.

The form described by Brongniart under the name of *Pecopteris nervosa* var. *oblongata* is shown on Pl. CXLIII, fig. 1, of which portions are enlarged two times at figs. 1*a* and 1*b*. The specimen probably shows the basal portion of the two primary pinnæ which form one of the two sections of the frond, but their connexion is not visible. The ultimate pinnæ are lanceolate and alternate, the pinnules are oblique to the rachis, narrow-triangular, decurrent, attached by all their base, and slightly united to each other. The median vein is decurrent and the lateral veinlets depart from it at a fairly acute angle, but owing to their being immersed it is difficult to trace their course distinctly. Some pinnules are enlarged two times at figs. 1*a* and 1*b* to show their form and the character of the nervation.

Another small specimen of the var. *oblongata* is given on Pl. CXLIII, fig. 2. It shows several fragments of pinnæ scattered over the surface of the small slab. On all of these the pinnules are sub-triangular, oblique to rachis, and slightly united to each other, and the basal posterior pinnule has a lateral lobe on its distal margin, but all the other pinnules are entire. The nervation when seen on the upper surface of the pinnule lies in a slight furrow. This is characteristic of the species when well preserved, and is also seen in the specimen described above. A few pinnules are enlarged two times at fig. 2*a*, Pl. CXLIII, which show this feature, and, although it is difficult to follow the course of the veinlets, their general arrangement is clearly indicated.

A peculiar, almost abnormal form of the var. *oblongata* is given natural size on Pl. CXLIV, fig. 5. The pinnæ springing from the right side of the rachis are typically those of the variety *oblongata*, while those on the left, especially on the lower pinna, bear long, linear pinnules, and the characteristic lobe of the posterior basal pinnule is long and narrow.

The specimen given natural size at fig. 1, Pl. CXL, which shows the dorsal surface, also falls under the var. *oblongata*. The straight rachis bears scattered short transversely-elongated bars and very fine longitudinal striations. The pinnæ are free, alternate, lanceolate, and slightly oblique, and their rachises bear small transverse bars. The sub-triangular pinnules are slightly broader in proportion to their length than those on the specimens which have just been described ; they are decurrent and oblique to the rachis, and are only united to each other by a very narrow band. The attachment of the posterior basal pinnule in the angle formed by the union of the two rachises is well seen on this specimen, though it can be observed on most of the specimens given in our figures.

The upper surface of the pinnules is beautifully preserved and has a very fine papillose appearance when examined with a lens. This is perhaps caused by the epidermal cells, though the small capillate glandular hairs described later may have played a part in producing the papillose roughness of the pinnule-surface. All the pinnæ on this example, whose terminations are complete, end in a spine-like point. An ultimate pinna is seen enlarged two times at fig. 1*a*, to show more distinctly the form and slight union of the pinnules to each other, and their nervation.

Another example of forma *nervosa* is given natural size on Pl. CXLIV, fig. 6. The pinnules here are smaller than usual. On the upper pinnæ some of them have the sub-triangular shape common to the *oblongata* form, but on the lower pinnæ especially the pinnules have bluntly rounded points and have lost their sub-triangular form. This example illustrates the variation in the shape of the pinnules that may occur on the same specimen. The pinnæ are also slightly contracted at base. An ultimate pinna, enlarged two times at fig. 6*a*, from near the top of the specimen, shows this variation in the form of the pinnules, but it is more marked on the pinnæ situated at the base.

Two small specimens are given on Pl. CXXXVIII, figs. 3 and 4. That at fig. 3, of which a part is enlarged two times at fig. 3*a*, should probably be referred to the variety *microphylla* of Brongniart,* but so many slight intermediate variations occur that one form passes imperceptibly into the other, and no line can be drawn between them. That given at fig. 4 shows a greater union of the pinnules to each other than the specimen just described, and though smaller in all its parts, it is apparently the form to which Brongniart gave the varietal name of *macrophylla*.† This example shows the nervation fairly well, and in the pinna enlarged two times at fig. 4*a* some of the pinnules appear as if a few of the veinlets were directly derived from the rachis, but in reality they are all derived from the median vein and join it before it unites with the vascular strand of the rachis, though the union of some of the lateral veinlets takes place within the rachis.‡

A much better example of the variety *macrophylla* is seen on the left side of the specimen given at fig. 7, Pl. CLIII.

Huth has described and figured some curious circular (though probably originally globular) outgrowths which have been found attached to the rachis of a *Mariopteris* which he refers to *Mariopteris muricata*, but from the pinnules associated with them, evidently belong to *Mariopteris nervosa*. Two of his figures are reproduced here. He did not think they were seeds, but suggests that they might be some gall-growths.§

According to Huth, Gothan in an article on Pteridosperms suggests that these small outgrowths might be vegetative propagation organs of the nature of bulbils or adventitious buds.||

These structures appear to be very rare, and the only British example I have seen was collected by Mr Hemingway, and is shown natural size on Pl. CXLIV, fig. 1. It consists of a fusiform organ about 1·5 cm. in length and 8 mm. in breadth, which terminates a short rachis, 3 mm. in width, which appears to be one of two arms of a dichotomously-divided rachis which springs from a stem 1 cm. in breadth. The other arm of the dichotomy is continued for a length of 2·5 cm., where it is broken over. The stem, lateral branch, and attached organ all bear the short, transversely-elongated, elevated ridges on their outer surface, and, in addition, the stem has longitudinal striations. Our specimen also occurs in association with pinnæ of *Mariopteris nervosa*. The real nature of the structure can only be conjectured, and the suggestion made by Gothan that it might be a propagative organ is perhaps the most probable.

I am indebted to Mr John Walton for some photographs of the epidermis of

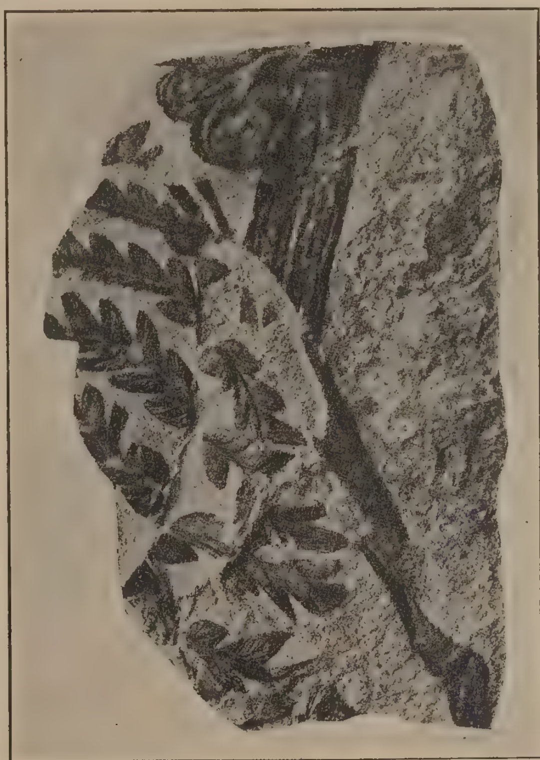
* *Loc. cit.*, pl. xcv, fig. 2. † *Loc. cit.*, pl. xcv, fig. 1. ‡ See *ante*, p. 596.

§ Huth, "Fossile Gattung *Mariopteris*," Inaugural-Dissertation (Berlin), p. 14, figs. 3, 4, and 5; 1912; also Huth in Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8 (1912), No. 141, p. 8, figs. 3, 4, 5.

|| See Huth in Potonié, *loc. cit.*, No. 141, p. 10.

Mariopteris nervosa,* showing its structure and appendages, which appeared in his paper describing his new transfer-method for the preparation of carbonized specimens for microscopical examination.† I am also indebted to him for the following descriptive details.

The surface of the frond is studded with capitate glandular hairs [Pl. CLIII, fig. 1]. These hairs occur in greater numbers on the abaxial surface of the frond, and are more abundant on the epidermis overlying the veins than on that overlying the rest of the lamina. Some of the cuticle-preparations made from portions of this



TEXT-FIGS. 88 and 89.—Bulbil-like structures on *Mariopteris nervosa* Brongniart sp. Copied from HUTH.

frond exhibited entire hairs in an apparently undamaged condition [Pl. CLIII, fig. 6]. Each hair consists of a stout, heavily cuticularized stalk with a broad base. The head of the hair, which was evidently of a glandular nature, shows traces of a finely cellular structure and is not cuticularized to the same extent. Microspores of various types are found sticking to the cuticles [Pl. CLIII, fig. 2], sometimes round the bases of the hairs and sometimes actually on the stalk of a hair. There seems thus to be good evidence for concluding that the hairs secreted a sticky fluid which caused the adherence of such large numbers of spores [Pl. CLIII, fig. 4]. The hairs which were on the surface of the plant originally exposed on the rock specimen have

* The specimen figured by Mr WALTON was identified by me as *Mariopteris* cf. *muricata* Schlotheim sp. At that time I considered *Mariopteris* (*Pecopteris*) *nervosa* Brongniart to be a form of *Mariopteris muricata*, but I now believe it to be a distinct species, and it is to *Mariopteris nervosa* Brongniart sp. that Mr WALTON's specimen belongs.

† WALTON, " On a New Method of investigating Fossil Plants," *Ann. of Bot.*, vol. xxxvii, p. 379, pl. ix, 1923.

naturally been broken off when the rock was split open. The position of these hairs is indicated by small holes in the cuticle-preparation from the adaxial surface of a pinnule [Pl. CLIII, fig. 2, *h, h*]. These holes correspond in number and also in size to the "atemporem," structures which Huth * compared with the air-pores of the Marchantiaceæ.

The cuticle of the abaxial surface [Pl. CLIII, fig. 3] is very different in type. It is thin and fragile, and the outline of the epidermal cells can be distinguished only with difficulty.

Groups of five to six small, heavily cuticularized papillæ [Pl. CLIII, fig. 3, *p*] occur at frequent regular intervals on the cuticle between the veins. The papillæ in each group surround a small area which in favourable examples is seen to be occupied by a small stoma of quite the usual type consisting of two curved guard cells surrounding a narrow elliptical pore [Pl. CLIII, fig. 5]. The papillæ are probably projections from the epidermal cells surrounding the stoma. There were approximately seventy-five stomata per sq. mm. of the abaxial surface [Pl. CLIII, fig. 3]. None were observed on the adaxial surface [Pl. CLIII, fig. 2].

The species with which *Mariopteris nervosa* is most likely to be mistaken is the *Mariopteris hirta* Stur sp., but in the latter species the pinnules are broader in proportion to their length, and have straighter sides and contract more slowly into a blunt point. This causes the pinnules to appear to be much closer together than in *Mariopteris nervosa.* The pinnules also are usually larger than those of *Mariopteris nervosa*, but when the latter species has large pinnules they are always much more gradually contracted upwards and have sharper points. If the two species be placed side by side their general appearance is very different. A comparison of the specimen of *Mariopteris hirta* given on Pl. CXLI, with the figures of *Mariopteris nervosa*, will show their distinctive characters better than any verbal description. The secondary pinnæ of *Mariopteris hirta* are also more linear, being of constant width for two-thirds or more of their length.

The differences which separate *Mariopteris nervosa* from *Mariopteris muricata* have been pointed out in our description of the latter species.

Distribution.—Mariopteris nervosa is found in the Radstockian Series, the Staffordian Series, the Westphalian Series, and the Lanarkian Series. In the latter two it is very common, but not so plentiful in the Staffordian Series.†

RADSTOCKIAN SERIES.

Somerset and Bristol Coalfield.

RADSTOCK GROUP.

Horizon: ?. *Locality:* Radstock, Somerset (Collection of British Museum, No. V. 1961).

* Huth, "Zur Kenntnis der Epidermis von *Mariopteris muricata*," *Zeitschr. deutsch. geol. Gesellsch.*, Band lxv, p. 143, 1913.

† I have recorded this species from the Radstockian Series, but now cancel the records until they are confirmed ("Foss. Flora Radstock Series," *Trans. Roy. Soc. Edin.*, vol. xxxiii, p. 363, 1888).

STAFFORDIAN SERIES.

Cumberland Coalfield.

BLACKBAND GROUP.

Horizon: Whitehaven Sandstones. *Locality:* Cliff Quarry, behind William Pit, Whitehaven (Collection of Geological Survey, London).

Kent Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: At depths of 1647–1649, 1780–1787 feet. *Locality:* Boring at Tower Brickworks, Folkestone (Collection of Geological Survey, London).

Horizon: At depth of 2684–2690 feet. *Locality:* Bere Farm Boring, $1\frac{3}{4}$ miles north-east of Dover (Collection of Geological Survey, London).

Lancashire Coalfield.

BLACKBAND GROUP.

Horizon: 200 yards from surface. *Locality:* Bradford Colliery, Manchester (W. Hemingway).

Horizon: Short distance above Bradford Four-foot Coal. *Locality:* Bradford Colliery, Manchester (W. Hemingway).

North Staffordshire Coalfield.

BLACKBAND GROUP.

Horizon: Above Bassey Mine. *Locality:* Cobridge Marl Pit, near Cobridge Station.

Horizon: Twelve yards above *Spirorbis* Limestone. *Locality:* Hewitt's Marl Pit, Fenton Low.

Somerset and Bristol Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: ?. *Locality:* Broad Oak Colliery, Pensford, 2 miles north-west of Cluttor, Somerset (R. Crookall); Bromley Colliery, 1 mile west of Pensford, Somerset (R. Crookall).

BLACKBAND GROUP.

Horizon: ?. *Locality:* Deep Pit, Kingswood, $3\frac{1}{2}$ miles north-east of Bristol, Gloucestershire.

South Wales Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: About position of Graigola Seam. *Locality:* Clydach Merthyr Colliery, 500 yards W.S.W. of Pen-y-banc Farm, Glamorganshire (Collection of Geological Survey, London).

BLACKBAND GROUP.

Horizon: About 25 feet above No. 1 Rhondda Seam. *Locality:* Craig Blaen, Rhondda Escarpment, $\frac{1}{4}$ mile N.W.N. of Blaen Rhondda Farm, Glamorganshire (Collection of Geological Survey, London).

Horizon: No. 2 Rhondda Seam. *Localities:* Cambrian Collieries, Clydach Vale, Rhondda (D. Davies); Standard Collieries, Ynyshir, Glamorganshire (*M. muricata* and var. *hirta*) (R. Weed); Dinas Main Level, Gilfach Goch, Glamorganshire (D. Davies).

Horizon: No. 3 Rhondda Seam. *Locality:* Glamorgan Colliery, Gilfach Goch, Glamorganshire (D. Davies).

Horizon: Three Coals (A) Seam. *Locality:* Glynogwr Colliery, Gilfach Goch, Glamorganshire (D. Davies).

Horizon: Upper Maesmelyn Seam. *Locality:* Clydach Colliery, Clydach, Glamorganshire (M. Galliver).

Horizon: Strata between Wenallt Seam and No. 2 Rhondda Seam. *Locality:* Glassbrook's Shaft, close to Cadoxton Village, Glamorganshire (Collection of Geological Survey, London).

WESTPHALIAN SERIES.

Ayrshire Coalfield.

Horizon: About 12 fathoms above Ell Coal. *Locality:* Lugar Water, Old Cumnock (J. Smith).

Horizon: About position of Ell Coal. *Locality:* Burnockhill Pit, Ochiltree (J. Smith).

Canonbie Coalfield.

Horizon: ?. *Locality:* Byre Burn, underneath railway viaduct, near Gilnockie Railway Station, Dumfriesshire.

Douglas Coalfield.

Horizon: 114 fathoms and 106 fathoms above Skipsey Marine Band, and 80 fathoms below it. *Locality:* Douglas, No. 2 Bore, south corner of Windrow Wood, $1\frac{1}{2}$ miles S.S.W. of Douglas, Lanarkshire (Collection of Geological Survey, Edinburgh).

Fife Coalfield.

Horizon: "Bed No. 28." *Locality:* Coast between River Leven and East Wemyss (J. W. Kirkby).*

Lanarkshire Coalfield.

Horizon: Pavement of Upper Coal (50 feet below Palace Craig Limestone). *Locality:* Kirkburn, Cambuslang (Collection of Geological Survey, Edinburgh).

* See Kidston "On the Various Divisions of British Carboniferous Rocks," *Proc. R. Phys. Soc. Edin.*, vol. xii, p. 201, 1894.

Horizon: Between Skipsey Marine Band and Upper Coal. *Locality:* 950 yards S.S.E. of Dykehead, south side of River, both on east and west sides of mineral-railway viaduct, 2 miles south-west of Coatbridge (Collection of Geological Survey, Edinburgh).

SANQUHAR COALFIELD.

Horizon: Three feet above Five-inch Coal, a few fathoms below Skipsey Marine Band. *Locality:* Polbower Burn, fully ¼ mile north of Kirkconnel Church, Sanquhar, Dumfriesshire (Collection of Geological Survey, Edinburgh).

Horizon: A few fathoms above Skipsey Marine Band. *Locality:* At fault on stream fully ½ mile north of Kirkconnel Church, Sanquhar, Dumfriesshire (Collection of Geological Survey, Edinburgh).

Horizon: About position of Skipsey Marine Band. *Locality:* Grass Cleuch, Kirkconnel, Dumfriesshire (J. SMITH).

Horizon: Ten feet above Caemstone Coal. *Locality:* The Gullet, Sanquhar, Dumfriesshire (Collection of Geological Survey, Edinburgh).

BURNLEY COALFIELD.

Horizon: Fulledge Thin or Yard Mine. *Locality:* New Shaft, Bank Hall Colliery, Burnley (P. WHALLEY).

CUMBERLAND COALFIELD.

Horizon: Above Cannel Coal. *Locality:* Robin Hood Pit, Flimby (E. A. N. ARBER).

Horizon: Above Main Band Coal. *Locality:* Walk Mill Pit, Moresby (E. A. N. ARBER).

FOREST OF WYRE COALFIELD.

Horizon: Brooch Coal. *Localities:* Kinlet Colliery, 1 mile south-west of Highley, Shropshire. Highley Colliery, Highley, Shropshire.

Horizon: "Sweet Coals." *Locality:* Billingsley Colliery, 1 mile south-west of Billingsley Church, Shropshire (E. A. N. ARBER).

Horizon: At a depth of 1973–1975 feet. *Locality:* Claverley Boring, 5 miles east of Bridgnorth, Shropshire (Collection of Geological Survey, London).

Horizon: Basal beds of the Series. *Locality:* Gully about 300 yards west of Riddings Barn on northern edge of wood, 1 mile north of Bewdley, Worcestershire.

INGLETON COALFIELD.

Horizon: Thick red measures overlying Crow Coal. *Locality:* Ingleton Colliery, Ingleton, Yorkshire (Collection of Geological Survey, London).

Horizon: Below Six-foot Seam. *Locality:* Ingleton Colliery, Ingleton, Yorkshire (Collection of Geological Survey, London).

Horizon: ?. *Locality:* River Greeta at Asylum Toll Bridge, near Burton-in-Lonsdale, Yorkshire (W. HEMINGWAY).

Lancashire Coalfield.

Horizon: Forty yards above Arley Mine. *Locality:* Spath, near Rochdale (W. H. Sutcliffe).

Horizon: Arley Mine. *Locality:* Hulton Colliery, near Bolton (Museum, Victoria University, Manchester).

Horizon: 144 yards and 828 yards below Bradford Four-foot Coal. *Locality:* Bradford Colliery, Manchester (J. Gerrard).

Horizon: Brassey Mine. *Locality:* Linnyshaw Pit, Worsley (J. Ainsworth).

Horizon: Doe Mine. *Locality:* Little Lever, near Bolton (J. Lomax).

Horizon: Midway between Flaggy Delf Coal and Rushy Park Coal. *Localities:* Doulton's Delf, St Helens (Gasking); Cropper's Hill, St Helens.

Horizon: Forest Bed. *Locality:* Oldham Edge, Oldham (J. Nield).

Horizon: King Coal. *Locality:* Kirkless Colliery, Wigan (Museum, Victoria University, Manchester).

Horizon: Peacock Coal. *Localities:* Rocher, Ashton-under-Lyne (J. Nield); Glodwick, Oldham (Oldham Museum).

Horizon: Potato Delf Coal. *Locality:* Lea Green Colliery, Lea Green, ¾ of a mile S.S.E. of Thath Heath Station (R. H. Goode).

Horizon: Ravenhead Coal. *Locality:* Ravenhead, St Helens (Liverpool Museum).

Horizon: Yard Mine. *Locality:* Hulton Colliery, near Bolton (Museum, Victoria University, Manchester).

Leicestershire and South Derbyshire Coalfield.

Horizon: Main Coal. *Locality:* Moira, Leicestershire (A. R. Horwood).

Horizon: Immediately above Block Coal (=Watson Coal). *Locality:* Stanton Colliery Clay Pit, 2½ miles south-east of Burton-on-Trent, South Derbyshire (R. D. Vernon).

North Derbyshire and Nottingham Coalfield.

NORTH DERBYSHIRE.

Horizon: Black Shale Coal. *Locality:* Denby Colliery, Denby (L. Moysey).

Horizon: A few yards below Black Shale Coal. *Locality:* Denby Colliery, Denby (Collection of Geological Survey, London).

Horizon: Between Deep Hard Coal and Silkstone Coal. *Locality:* Bondsmain Colliery, 3 miles S.S.E. of Chesterfield (Collection of Geological Survey, London).

Horizon: Dunsil Coal. *Locality:* Tibshelf Marl Pit, Tibshelf (L. Moysey).

Horizon: Above Kilburn Coal. *Locality:* Oakwell Colliery, Ilkeston (L. Moysey).

Horizon: Mickley Coal. *Locality:* Denby Colliery, Denby (M. Fryar).

Horizon: Piper Coal. *Locality:* Ilkeston Clay Pit, Ilkeston (L. Moysey).

Horizon : Silkstone Coal. *Localities :* Calow Colliery, Chesterfield (L. Moysey) ; Bondsmain Colliery, Temple Normanton, 3 miles S.S.E. of Chesterfield (L. Moysey).

Horizon : Below Top Hard Coal. *Locality :* Shipley Clay Pit, Ilkeston (L. Moysey).

Horizon : Waterloo Coal. *Locality :* Loscoe Marl Pit, Heanor (L. Moysey).

Horizon : ?. *Locality :* Clay Cross, 4½ miles south of Chesterfield (Chesterfield Museum).

NOTTINGHAMSHIRE.

Horizon : Between Rider Coal and Top Hard Coal. *Locality :* Stoney Lane Marl Pit, Brinsley (Collection of Geological Survey, London).

Horizon : 445 yards above Top Hard Coal. *Locality :* Mansfield Colliery, Crown Farm (Collection of Geological Survey, London).

Horizon : Top Hard Coal. *Locality :* Digby Clay Pit, Kimberley (L. Moysey).

Horizon : Between Top Hard Coal and Deep Soft Coal. *Locality :* Newthorp Clay Pit, Eastwood (L. Moysey).

Horizon : Between Waterloo Coal and Ell Coal. *Locality :* Newthorp Clay Pit, Eastwood (L. Moysey).

North Staffordshire Coalfield.

Horizon : Bay Coal. *Locality :* Longton (J. Ward).

Horizon : Bowling Alley Rock. *Locality :* Adderley Green, near Longton (J. Ward).

Horizon : Great Row Coal. *Locality :* Longton (J. Ward).

Horizon : Great Row Coal Rock. *Locality :* Stafford Iron and Coal Company, Fenton (J. Ward).

Horizon : Two yards below Hard Mine Coal. *Locality :* Weston Coyney Colliery, near Longton.

Horizon : Eighteen and twenty yards below Hard Mine Coal. *Locality :* Sneyd Colliery, near Burslem (J. T. Stobbs).

Horizon : Holly Lane Coal. *Locality :* Bucknall.

Horizon : Sixteen yards above Moss Coal. *Locality :* Florence Colliery, Longton (J. Ward).

Horizon : Moss Coal. *Locality :* Lane End, Fenton.

Horizon : Strata between Moss Coal and Holly Lane Coal. *Locality :* Lane End, Fenton (W. Hind).

Horizon : Strata between Holly Lane Coal and Bowling Alley Coal. *Locality :* Sneyd Colliery, near Burslem (J. T. Stobbs).

Horizon : Knowles Ironstone. *Localities :* Stafford Iron and Coal Company, Fenton (J. Ward) ; Longton (J. Ward).

Horizon : Seven-foot Bambury Coal. *Locality :* Jamage Colliery, near Audley.

Northumberland and Durham Coalfield.

NORTHUMBERLAND.

Horizon : Low Main Seam. *Locality :* Cramlington (J. Sim).

Horizon : Yard Seam. *Locality :* Shiremoor, 3½ miles north-west of Tynemouth (Hancock Museum, Newcastle-upon-Tyne).

DURHAM.

Horizon : Bensham Seam. *Locality :* Jarrow Colliery, Jarrow.

Horizon ; Crow Coal. *Locality :* Phœnix Brickworks, Crawcrook, Ryton (W. Eltringham).

Horizon : Five-quarter Seam. *Locality :* West Thornley Colliery, Tow Law (J. T. Stobbs).

Horizon : High Main Seam. *Locality :* Felling.

Horizon : Strata between Hutton Seam and Harley Seam. *Locality :* Mainsforth Colliery, Ferryhill (J. H. Adamson).

Horizon : Low Main Seam. *Locality :* Felling (Hancock Museum, Newcastle-upon-Tyne).

Horizon : Stone Coal. *Locality ;* Stargate Colliery, Ryton (W. Eltringham).

Horizon : Three-quarter Seam. *Locality :* Chopwell, 2½ miles north-east of Ebchester (P. Charlton).

Horizon : Under Five-quarter Coal (=Six-quarter Seam). *Localities :* Stargate Colliery, Ryton (W. Eltringham) ; Elizabeth Pit, Tanfield Lea (W. Eltringham).

South Staffordshire Coalfield.

Horizon : Roof of Bottom Coal. *Locality :* No. 120 Conygre Pit, Tipton (H. W. Hughes).

Horizon : Immediately below Bottom Coal. *Locality :* Ruiton, near Sedgley.

Horizon : Blue Measures, 6 feet above Brooch Coal. *Locality :* Hamstead Colliery, Great Barr, 2½ miles south-east of Walsall (H. Insley).

Horizon : Brooch Coal. *Localities :* Pensnett, 2 miles south-west of Dudley ; Himley, 4 miles W.N.W. of Dudley ; Shut End, Kingswinford ; Foxyards, Dudley.

Horizon : Fire Clay Coal. *Locality :* Netherton Dudley.

Horizon : Between Fire Clay Coal and Bottom Coal. *Locality :* Netherton, Dudley.

Horizon : Roof of New Mine Coal. *Localities :* Doulton's Clay Pit, Netherton, Dudley (H. W. Hughes) ; Coseley, near Dudley ; Mount Pleasant, Brierley Hill, 2½ miles north-east of Stourbridge.

Horizon : Thirty-one yards above Thick Coal. *Locality :* Hamstead Colliery, Great Barr, 2½ miles south-east of Walsall (Meachem).

Horizon : Ten-foot Ironstone Measures. *Locality :* Clayscroft Openworks, Coseley, near Dudley (H. W. Hughes).

Horizon : Thick Coal. *Locality :* Bradley Colliery, Bilston, 2½ miles south-east of Wolverhampton.

Horizon : 717 yards from surface. *Locality :* East trial road, Jubilee Pit, Sandwell Park, West Bromwich (H. W. HUGHES).

TITTERSTONE CLEE HILL COALFIELD.

Horizon : Between Four-foot Coal and Gutter Coal. *Locality :* Chimney Pit Boring, Angelbank, Titterstone Clee, Shropshire (R. L. ROBERTS).

Horizon : Roof of Great Coal. *Locality :* Whatsill Colliery, Clee Hill, Shropshire (E. E. L. DIXON).

Horizon : Strata some distance above Great Coal. *Locality :* Penny's Pit, near Collybrook Cottage, Knowbury, Shropshire (E. E. L. DIXON).

Horizon : Near Gutter Coal. *Localities :* Pit near Winthills Wood, Knowbury, Shropshire (E. E. L. DIXON) ; Colliery, 350 yards north-east of St Paul's Church, Knowbury, Shropshire (E. E. L. DIXON).

Horizon : Roof of Gutter Coal. *Locality :* Colliery, 130 yards W.S.W. of Craven Cottage, Catherton, Shropshire (E. E. L. DIXON).

Horizon : Five feet below Smith Coal. *Locality :* Chimney Pit Boring, Angelbank, Titterstone Clee, Shropshire (R. L. ROBERTS).

WARWICKSHIRE COALFIELD.

Horizon : Ryder Coal. *Localities :* Kingsbury Colliery, 5½ miles south of Tamworth (R. D. VERNON) ; Arley Colliery, 5 miles west of Nuneaton (R. D. VERNON).

Horizon : Seven-foot Coal. *Locality :* Chilvers Coton Clay Pit, Heath End, Nuneaton (R. D. VERNON).

Horizon : Thick Coal. *Localities :* Griff Colliery, Clara Pit, 2½ miles south-west of Nuneaton (R. D. VERNON) ; Wyken Colliery, 3 miles north-east of Coventry (R. D. VERNON) ; Nuneaton Colliery, about 2 miles west of Nuneaton (R. D. VERNON).

Horizon : Slate Coal. *Locality :* Wyken Colliery, 3 miles north-east of Coventry (A. R. HORWOOD).

YORKSHIRE COALFIELD.

Horizon : Barnsley Coal. *Localities :* Hargreave's Colliery, Woodhouse Mill, near Rotherham (W. GELDER) ; Roundwood Colliery, Kilnhurst, near Rotherham (W. GELDER) ; Cadeby Colliery, near Rotherham (W. GELDER) ; Treeton Colliery, near Rotherham (W. GELDER) ; South Kirkby Colliery, near Pontefract (W. HEMINGWAY) ; Woolley Colliery, Darton, near Barnsley (W. HEMINGWAY) ; Mount Osborne Colliery, near Barnsley (W. HEMINGWAY) ; East Gawber Colliery, near Barnsley (W. HEMINGWAY) ; Monckton Main Colliery, near Barnsley (W. HEMINGWAY) ; Elsecar Colliery, Elsecar, 5½ miles south-east of Barnsley (DURNFORD) ;

Kilnhurst Colliery, near Rotherham; Frickley Colliery, near Doncaster (W. Gelder); Clay Hole, Gawber, near Barnsley (W. R. Barker); Rosa Colliery, near Barnsley (W. Hemingway); North Gawber Colliery, near Barnsley (W. Hemingway).

Horizon: At depth of 100 yards and 120 yards below Barnsley Coal. *Locality:* Oaks Colliery, near Barnsley (W. Hemingway).

Horizon: Blue bind above Beeston Coal. *Localities:* Clark Lane, Leeds (J. W. Bond); Marsh Lane Tunnel, Leeds (J. W. Bond).

Horizon: Better Bed Coal. *Locality:* Low Moor, near Bradford (J. Spencer).

Horizon: Shales immediately below Better Bed Coal. *Locality:* Quarry, Brickworks, Seymour Street, Bradford (M. A. Johnston).

Horizon: Birdwell Rock. *Locality:* Oaks Colliery, near Barnsley (W. Hemingway).

Horizon: Roof of Black Bed Coal. *Localities:* Dark Lane Pit, Mirfield Coal Co., Mirfield (S. Nettleton); Low Moor, near Bradford (J. Spencer).

Horizon: Below Black Bed Coal. *Locality:* Patent Brick Co.'s Quarry, Dolly Lane, Leeds (J. W. Bond).

Horizon: Black Bed Ironstone. *Locality:* Low Moor, near Bradford (J. Spencer).

Horizon: Shale over Chevet Rock. *Locality:* Cadeley Colliery, Conisborough (W. Hemingway).

Horizon: Above Crow Coal. *Localities:* Quarry, Stoney Park, Leeds (J. W. Bond); Dolly Lane, Leeds (J. W. Bond).

Horizon: Below Crow Coal. *Locality:* Quarry, Stoney Park, Leeds (J. W. Bond).

Horizon: Dewsbury Rock. *Locality:* Dewsbury Moor, Dewsbury (Tindal).

Horizon: In strata 43 feet and 37 feet above Haigh Moor Coal. *Locality:* Quarry at Robin Hood, 4 miles south of Leeds (A. Burnet).

Horizon: Rock below Haigh Moor Coal. *Locality:* Brightside, near Sheffield (W. Hemingway).

Horizon: Houghton Common Rock. *Locality:* Brierley Tunnel, near Barnsley (W. Hemingway).

Horizon: Milton Field Coal (Half-yard Coal). *Locality:* Monkey Island Pit, Wath, near Barnsley (W. Gelder).

Horizon: Oaks Coal. *Locality:* Hoyle Mill, Barnsley (W. Hemingway).

Horizon: Shale over Oaks Rock. *Locality:* Micklethwaites Brickyard, Stairfoot, near Barnsley (W. Hemingway).

Horizon: Shale underneath Oaks Rock. *Locality:* Sinking, Pontefract Road, Barnsley (W. R. Barker).

Horizon: Old Hards Coal. *Locality:* Hartley Bank Colliery, Horbury.

Horizon: Parkgate Coal. *Locality:* Rockingham Colliery, Barnsley (W. Hemingway).

Horizon: Ninety yards above Shafton Coal. *Localities:* New Frickley Colliery, Frickley (W. Hemingway); Brierley Colliery, Brierley, near Barnsley (W. R. Barker).

Horizon: Stanley Main Coal. *Localities:* Shale Quarry, Roundwood, Osset (S. Nettleton); Wakefield (W. Gelder).

Horizon: Swallow Wood Coal. *Locality:* Oaks Colliery, near Barnsley (W. Hemingway).

Horizon: Twenty, thirty, and fifty yards below Swallow Wood Coal. *Locality:* Oaks Colliery, Barnsley (W. Hemingway).

Horizon: White Rake Bed. *Locality:* Low Moor, near Bradford (Davis).

Horizon: Woolley Edge Rock. *Locality:* Oaks Colliery, near Barnsley (W. Hemingway).

Anglesea Coalfield.

Horizon: "Berw Beds." *Locality:* Berw.

North Wales Coalfield.

FLINTSHIRE.

Horizon: Four-foot Coal. *Locality:* Flint Marsh Colliery, about $\frac{3}{4}$ mile N.N.W. of Flint Station (Collection of Geological Survey, London).

Horizon: Hollin Coal. *Locality:* Main Coal Company's Pit, $3\frac{3}{8}$ miles north-west of Hawarden Station (Collection of Geological Survey, London).

Horizon: Roof of Main Coal. *Locality:* New Ash Colliery, $2\frac{1}{2}$ miles south-west of Hawarden Station (Collection of Geological Survey, London).

Horizon: Shale 33 yards above Yard Coal. *Locality:* Sinking at Cefn-y-Coed Colliery, near Potybodkin (Collection of Geological Survey, London).

Horizon: Yard Coal. *Locality:* Phœnix Coal and Cannel Company's Pit, $3\frac{1}{8}$ miles S.S.E. of Mold Station (Collection of Geological Survey, London).

DENBIGHSHIRE.

Horizon: Diamond Coal. *Locality:* Brynkinalt Colliery, nearly 1 mile north-east of Chirk Station (Collection of Geological Survey, London).

Horizon: Powell Seam. *Locality:* Vron Colliery, $2\frac{1}{2}$ miles north-west of Wrexham (Collection of Geological Survey, London).

Horizon: Two-yard Coal. *Locality:* Llay Hall Colliery, $2\frac{7}{8}$ miles N.N.W. of Wrexham (Collection of Geological Survey, London).

Horizon: Wall and Bench Seam. *Locality:* Bryn-Mally Colliery, $2\frac{3}{4}$ miles N.N.W. of Wrexham (Collection of Geological Survey, London).

Horizon: Yard Coal. *Locality:* Hafod-y-bwch Colliery, $2\frac{5}{8}$ miles S.S.W. of Wrexham (Collection of Geological Survey, London).

Horizon: Yard and a half Coal. *Locality:* Black Park Colliery, $1\frac{3}{8}$ miles north-east of Chirk Station (E. Plunkett).

SOUTH WALES COALFIELD.

Horizon: Abergorky Seam. *Locality:* Blaenclydach Colliery, Clydach Vale, Glamorganshire (D. DAVIES).

Horizon: Aberdare Four-foot Seam. *Locality:* Maesteg, Glamorganshire (C. BRADSHAW).

Horizon: Big Vein. *Localities:* Carway Colliery, 3¼ miles east of Kidwelly Church, Carmarthen (Collection of Geological Survey, London); Trimsaran Colliery, Trimsaran, 3 miles E.S.E. of Kidwelly, Carmarthen (Collection of Geological Survey, London).

Horizon: Black Vein. *Locality:* Risca, Monmouth.

Horizon: Fire Clay Bed below Nine-foot Seam. *Locality:* Cribbwr Brickworks, near Aberkenfig, Glamorganshire.

Horizon: Five-foot Seam (=Seven-foot Seam of Clydach Vale). *Locality:* Britannic Collieries, Gilfach Goch, Glamorganshire (D. DAVIES).

Horizon: Four-foot Rider Seam. *Locality:* Nantgwyn Colliery, Penygraig, Rhondda, Glamorganshire (D. DAVIES).

Horizon: Four-foot Seam. *Localities:* Fochriw, Glamorganshire (W. GALLIVER); Trane Colliery, Gilfach Goch, Glamorganshire (D. DAVIES).

Horizon: Gorllwyn Seam. *Locality:* Trane Colliery, Gilfach Goch, Glamorganshire (D. DAVIES).

Horizon: Hafod Rider Seam. *Locality:* Hills Plymouth Colliery, Pentrebach, near Merthyr, Glamorganshire (D. DAVIES).

Horizon: Lower Nine-foot Seam. *Locality:* Cambrian Colliery, Clydach Vale, Rhondda, Glamorganshire (D. DAVIES).

Horizon: Meadow Vein. *Localities:* New Tredgar, Monmouthshire (M. GALLIVER); Llanech Colliery, near Abersychan, Monmouthshire.

Horizon: Nine-foot Seam. *Localities:* Trane Colliery, Gilfach Goch, Glamorganshire (D. DAVIES); Bwllfa Dare Colliery, Aberdare, Glamorganshire.

Horizon: Red Seam. *Localities:* Cambrian Collieries, Clydach Vale, Rhondda, Glamorganshire (D. DAVIES); Near village of Pen-rhiw-fawr, Glamorganshire (Collection of Geological Survey, London).

Horizon: Seven-foot Seam (= Five-foot Seam of Gilfach Goch). *Locality:* Clydach Vale, Glamorganshire (D. DAVIES).

Horizon: Six-foot Seam. *Locality:* Trane Colliery, Gilfach Goch, Glamorganshire (D. DAVIES).

Horizon: Upper Two-foot nine-inch Seam (= Three Coals (B)). *Locality:* Pandy Pit, Tonypandy, Rhondda, Glamorganshire (D. DAVIES).

PEMBROKESHIRE.

Horizon: One-third way between "Farewell" Rock and Kilgetty Vein. *Locality:* Shales, 300 yards north-east of Ewerton, and 1¼ miles E. 5° N. of Martletwy (Collection of Geological Survey, London).

Horizon: ? Shales associated with Kilgelly Vein. *Locality:* Railway Cutting, 325 yards N.N.W. of Trewern, and $1\frac{1}{2}$ miles S. 10° E. Templeton Church (Collection of Geological Survey, London).

Horizon: ?. *Localities:* Lower part of outcrop of beds, 120 to 180 yards north-east of high-water mark, Rickets Head (Collection of Geological Survey, London); south-east corner of the Settlings, Little Haven (Collection of Geological Survey, London); Tip, old coal pit, 110 yards south of Black Cliff (Collection of Geological Survey, London); North sands, south side of first point, 900 yards north of Tenby Church (Collection of Geological Survey, London); Shore, centre of Settlings Bay, north of Little Haven (O. T. JONES); between Silver Top and Rooks Bay, south of Little Haven (O. T. JONES); Shore cliffs, 200 yards S.S.E. of Saundersfoot Harbour (Collection of Geological Survey, London); Shales at foot of cliff, 450 yards west of Monkston Point and about 350 yards north-east of Trevane (Collection of Geological Survey, London); South side of Settlings, Little Haven (O. T. JONES); Little Settlings, near Little Haven (O. T. JONES); Shore cliffs, 200 yards south of Waterwynch, 1580 yards north, 20° east of Tenby Railway Station (Collection of Geological Survey, London); 1 to 30 feet above Coal in shore cliffs, about 50 yards north of cascade, 550 yards south of Trevane (Collection of Geological Survey, London); Monkstone Bay, roof of impure Coal (the highest of three), about 150 yards south of zigzag path, $\frac{1}{4}$ mile E.S.E. of Trevane (Collection of Geological Survey, London).

LANARKIAN SERIES.

AYRSHIRE COALFIELD.

Horizon: Annandale Coal. *Locality:* Windyedge Pit, near Crosshouse.

Horizon: Four fathoms below Bowbrig Coal. *Locality:* Ardeer Pit, Stevenston (J. SMITH).

Horizon: Eighteen feet above Durroch Coal. *Localities:* Woodhill Quarry, Kilmaurs; Excavation for Gasometer, Holm Quarry, Kilmarnock (A. SINCLAIR).

Horizon: Between Ell and Main Coal. *Locality:* Barony Pit Shaft, Auchinleck (Collection of Geological Survey, Edinburgh).

Horizon: Sixteen to seventeen feet below Five-quarter Coal. *Locality:* Ardeer Pit, Stevenston (J. SMITH).

Horizon: Hurlford Main Coal. *Locality:* Wellington Pit, Kilmarnock (A. SINCLAIR).

Horizon: Kilwinning Main Coal. *Locality:* Borough Pit, Irvine.

Horizon: ? Kilwinning Main Coal. *Locality:* Hillhead Pit, Kilmarnock.

Horizon: Main Coal. *Locality:* No. 10 Pit, Springside Colliery, Dreghorn.

Horizon: Major Coal. *Locality:* No. 3 Springhill Pit, Crosshouse.

Horizon: Stranger Coal. *Locality:* Grange Pit, Kilmarnock.

Horizon: Tourha Coal. *Locality:* Warrix No. 2 Pit, Dreghorn (J. SMITH).

Horizon: Whistler Coal. *Locality:* Bonnington Pit, Kilmarnock.

Horizon: ?. *Localities:* Gauchallan Pit, Galston; Lucknow Pit, Stevenston.

Canonbie Coalfield.

Horizon : Five-foot Coal. *Locality :* Blinkbonny Pit, Rowanburn, Dumfriesshire.

Horizon : Main Coal. *Locality :* Engine Pit, Rowanburn, Dumfriesshire.

Clackmannanshire Coalfield.

Horizon : Blairingone Coal. *Localities :* Blairingone, near Dollar; Kellybank, near Dollar.

Horizon : Lower Five-foot Coal. *Locality :* Devon Colliery, Old Devon Ironworks, 1 mile south-west of Tillicoultry (Collection of Geological Survey, Edinburgh).

Horizon : ?. *Localities :* Tullygarth Pit, near Clackmannan; Mine, Devonside, Tillicoultry (J. Lyon).

Fifeshire Coalfield.

Horizon : Upper Coxtool Coal (= Six-foot Coal). *Locality :* East Newton, Wemyss (J. Kirby).

Horizon : Near base of Coal-bearing strata. *Locality :* Blairpoint, Dysart.

Horizon: Wood Coal. *Locality :* Pirnie Colliery, Leven (J. Kirby).

Horizon : ?. *Locality :* Newton Old Pit, Wemyss (Collection of Geological Survey, London).

Lanarkshire Coalfield.

Horizon : Ell Coal. *Locality :* Pit, 250 yards north by east of Uddingston (Collection of Geological Survey, Edinburgh).

Horizon : Kiltongue Coal. *Localities :* Bent Colliery, about 1½ miles east of Bothwell; Calderbank, near Airdrie (R. Dunlop); Greengairs, near Airdrie (R. Dunlop); Lochwood Colliery, Easterhouse (R. Dunlop); Mount Vernon (R. Dunlop); Clyde Pit, Carmyle (R. Dunlop); Whiterigg Colliery, near Airdrie (R. Dunlop).

Horizon : Between Kiltongue Coal and Upper Drumgray Coal. *Locality :* Whiterigg Colliery, near Airdrie (R. Dunlop).

Horizon : Sixteen to seventeen feet above Pyotshaw Coal. *Locality :* Garrion Burn, ½ mile east of Overtown (Collection of Geological Survey, Edinburgh).

Horizon : Upper Drumgray Coal. *Locality :* Pit near Calder Ironworks, Airdrie.

Horizon : Between Virgin Coal and Kiltongue Coal. *Locality :* Lochwood Colliery, No. 3 Pit, Dungeon Hill, Easterhouse.

Horizon : Pavement of Virtuewell Coal. *Locality :* Pit at Heatheryknowe House, 2 miles west of Coatbridge (Collection of Geological Survey, Edinburgh).

Horizon : ?. *Localities :* Auchanheath, Lesmahagow; Chapelhall, near Airdrie; Howlit Glen, Crossford, Lesmahagow; Hallhill Burn (tributary of River Nethan), fully 1 mile south-west of bridge across River Clyde at Crossford (Collection of Geological Survey, Edinburgh).

Midlothian Coalfield.

Horizon: Diamond or Splint Coal. *Locality:* Whitehall Colliery, Rosewell (Collection of Geological Survey, Edinburgh).

Horizon: Within a few feet of the Seven-foot Coal. *Locality:* Joppa shore, east of Saltpans (Collection of Geological Survey, Edinburgh).

Horizon: Millstone Grit Bed underlying *Carbonicola* bed. *Locality:* West division of Harbour, Port Seton (Collection of Geological Survey, Edinburgh).

Horizon: Millstone Grit. *Locality:* Bed on east side of Harbour, Port Seton (Collection of Geological Survey, Edinburgh).

Horizon: Millstone Grit. *Locality:* River South Esk, at Prestonholm, about ½ mile south of Dalhousie Castle on left bank of stream (Collection of Geological Survey, Edinburgh).

Horizon: ?. *Localities:* Right bank of River Esk, down stream from Weir (Collection of Geological Survey, Edinburgh); Pit Sinking, Olive Bank, south of Fisherrow Harbour, Musselburgh (Collection of Geological Survey, Edinburgh).

Stirlingshire Coalfield.

Horizon: Auchengane Coal. *Locality:* Greenbank, 1¼ miles W.S.W. of Falkirk (Collection of Geological Survey, Edinburgh).

Horizon: Ball Coal. *Localities:* Meadowbank Pit, ½ mile south of Polmont (Collection of Geological Survey, Edinburgh); No. 13 Callender Pit, ½ mile S.S.E. of the Glen, 1½ miles south of Falkirk (Collection of Geological Survey, Edinburgh); No. 23 Pit, Redding, near Polmont (C. McLuckie).

Horizon: Upper Coxroad Coal. *Locality:* The Cleuch, Falkirk (C. W. Peach).

Horizon: Coxroad Coal. *Localities:* No. 14 Callender Pit, about 2⅞ miles S.S.W. of Falkirk (Collection of Geological Survey, Edinburgh); Crosscroes Colliery, 1¼ miles east of Loch Ellrig (Collection of Geological Survey, Edinburgh).

Horizon: Slatyband Ironstone. *Locality:* One-eighth mile east of Muirhead, and 1½ miles S.S.E. of Cumbernauld Station (Collection of Geological Survey, Edinburgh).

Horizon: Splint Coal. *Locality:* Pit near California, 2½ miles S.E. of Falkirk (Collection of Geological Survey, Edinburgh).

Horizon: Shale mined for Alum making. *Locality:* Cleuch Glen, 1½ miles south of Falkirk (Collection of Geological Survey, Edinburgh).

Horizon: ?. *Localities:* Redford Colliery, Bowhouse; Candie Pits, Bowhouse.

Burnley Coalfield.

Horizon: Forty yards or Upper Mountain Mine. *Locality:* Bacup (C. Dugdale).

Horizon: Roof of Ganister Mine. *Locality:* Old Meadows Pit, Bacup (Bacup Museum).

Horizon: Mountain Four-foot Seam. *Locality:* Fox Clough, Colne (P. WHALLEY).

Horizon: Soapstone Bed above Bullion Coal. *Locality:* Trawden, near Colne (G. WILD).

FOREST OF WYRE COALFIELD.

Horizon: At depth of 2127 feet. *Locality:* Claverley Boring, 5 miles east of Bridgnorth, Shropshire (Collection of Geological Survey, London).

LANCASHIRE COALFIELD.

Horizon: Middle Mountain Mine. *Locality:* Bickerstaffe Colliery, about 1 mile north of Rainford Junction (R. H. GOODE).

Horizon: Sandrock Mine. *Locality:* Ashworth Colliery, Keywood (Museum, Victoria University, Manchester).

NORTH STAFFORDSHIRE COALFIELD.

Horizon: Below Fifth Grit. *Locality:* Bed of River Dane, $\frac{1}{6}$ mile south of Bosley Railway Station (Collection of Geological Survey, London).

Horizon: Millstone Grit. *Locality:* Kerridge, Macclesfield.

YORKSHIRE COALFIELD.

Horizon: Millstone Grit. *Locality:* Cold Edge, Halifax (W. CASH).

Horizon: Millstone Grit; Third Grit. *Locality:* Luddenden, Halifax (J. SPENCER).

Horizon: Millstone Grit; Fourth Member of Third Grit. *Locality:* Sowerby, near Sowerby Bridge (T. SALTONSTALL).

Mariopteris Sauveuri Brongniart sp.

Plate CXLII, figs. 1–4.

1833. *Pecopteris Sauveuri* Brongniart, "Hist. des végét. foss.," p. 299, pl. xcv, fig. 5.

1836. *Alethopteris Sauveuri* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.* xvii, p. 311. (*Refs. in part.*)

1883. *Diplothmema Sauveuri* Stur, "Morph. u. System. d. Culm-und Carbonfarne," *Sitzb. k. Akad. Wissensch.*, Band lxxxviii, Abth. 1, p. 194.

1885. *Diplothmema Sauveuri* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 380, pl. xxiv, figs. 2–4.

1899. *Mariopteris Sauveuri* Frech, "Lethaea geogn.," Teil 1, "Lethaea palaeoz.," Band ii, Lief. 2, Steinkohlenfl., pl. 50*a*, fig. 6.

1915. *Mariopteris muricata* forma *Sauveuri* Jongmans and Gothan, "Palaeobot.-strat. Studien," *Archiv für Lagerstättenforschung*, No. 18 (*K. preuss. geol. Landesanst.*), p. 175, pl. vi, figs. 1, 2.

1923. *Mariopteris muricata* forma *Sauveuri* Gothan in GÜRICH, "Leitfossilien," Lief. 3, p. 40, pl. ii, fig. 1.

1912. *Mariopteris muricata* Huth (*non* Schlotheim), "Fossile Gattung *Mariopteris*," Inaugural-Dissertation (Berlin), p. 16, fig. 6.
1912. *Mariopteris muricata* Huth (*non* Schlotheim) in Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8, No. 141, p. 11, fig. 6.
1912. Cf. *Mariopteris muricata* Huth (*non* Schlotheim), "Ueber die Epidermis von *Mariopteris muricata*," *Palaeobot. Zeitschrift*, vol. i, p. 7, pl. i, figs. 1, 2; pl. ii, figs. 5–10.
1913. Cf. *Mariopteris muricata* Huth (*non* Schlotheim), "Kenntnis der Epidermis von *Mariopteris muricata*," *Zeitschr. deutsch. geol. Gesellsch.*, Band lxv, Monatsbericht No. 3, p. 143, figs. 1–8.
1869. *Mariopteris nervosa* Schimper (*non* Brongniart) (*pars*), "Traité de paléont. végét.," vol. i, p. 513, pl. xxx, figs. 6, 7.
1886. *Mariopteris muricata* forma *nervosa* Zeiller (*non* Schlotheim) (*pars*), "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 173, pl. xxii, fig. 1.
1910. *Mariopteris muricata* forma *nervosa* Schmitz (*non* Brongniart) in Renier, "Documents pour l'étude de la paléont. du terr. houil.," pl. lxxxiii.
1848. *Pecopteris heterophylla* Sauveur (*non* Brongniart), "Végét. foss. terr. houil. de la Belgique," pl. xlvii (*Nouv. Mém. Acad. Roy., Brussels*).

Description.—Petiole naked, 7 mm. or more in breadth, with numerous transversely-elongated ridges, bifurcating at top at a very open angle into two arms about 2 cm. in length and 3 mm. or more in breadth, which also bear small transversely-elongated ridges and divide the frond into two sections. These two arms again dichotomize, and the resulting branches form the straight or slightly flexuous barred rachises of the four primary pinnæ which compose the frond. The two upper pinnæ are somewhat larger than the lower pair. Secondary pinnæ linear-lanceolate, free, touching laterally or slightly overlapping, rachis straight, ending in a blunt or pointed terminal lobe and attaining a length of at least 7 cm. On the upper pair of primary pinnæ the secondary pinnæ are of almost equal length on both sides of the rachis; on the lower pair, the secondary pinnæ within the angle are shorter than those arising from the outer margin of the pinnæ.

Pinnules slightly oblique to rachis, decurrent, short-oblong, with blunt rounded apices; a few at the base of the lower-situated pinnæ free. Posterior basal pinnule sub-rotund, entire, or with a slight, rounded lateral lobe. The other pinnules become more and more united to each other towards the apex of the pinnæ, and on the pinnæ situated close to the apex of the primary pinnæ the pinnules are so much united to each other that individually they are only indicated by blunt lobes, which form a crenate margin to the pinnæ; and finally the pinnæ assume the form of elongated sharp-pointed entire pinnules, whose median vein frequently projects as a spine-like point.

Nervation immersed and usually very indistinct. Median vein strong, straight, or slightly decurrent, and extending to near the apex of the pinnule, where it sometimes seems to divide into two arms; lateral veinlets depart at an acute angle and take an almost straight upward course to the margin. They usually dichotomize once, but those at the base of the pinnule may undergo a further division.

Remarks.—Four specimens of *Mariopteris Sauveuri* are illustrated on Pl. CXLII. That given at fig. 4 shows three of the four primary pinnæ which formed the complete frond. The rachis is not very perfect, but it shows the transverse ridges and dichotomizes at its apex into two arms. These again dichotomize, but of the two arms to the right which form the primary pinnæ one has unfortunately been broken off. The two upper primary pinnæ are larger than the lower ones, and the secondary pinnæ springing from them are of almost equal length on both sides of the rachis, while those arising from the rachises of the two lower primary pinnæ are much shorter on the side within the fork than on its outer side. These features are also seen on the larger specimen figured by Stur.*

The two upper primary pinnæ are slightly contracted at the base and become gradually narrower from about the middle upwards and end in a sharp point. On this specimen all the pinnules are more or less united to each other; even the basal posterior pinnule is not free, and, though larger than the others, has no lateral basal lobe. The pinnules are slightly oblique to the rachis, decurrent, and have more or less obtuse apices. On this example the pinnules on the distal side of the rachis are slightly larger than those of the proximal side.

Towards the apex of the primary pinnæ, the pinnules of the secondary pinnæ become gradually more and more united to each other, till finally the pinnæ assume the form of elongated pinnules. Not only from the small size of this frond, but also from the extent of union of the pinnules to each other on the basal secondary pinnæ, it seems probable that this frond was derived from a younger individual than that which bore the frond figured by Stur † or those which yielded the fragments given here on Pl. CXLII, figs. 1–3.

The apex of a primary pinna is given natural size at fig. 1. On the lower-situated secondary pinnæ some of the pinnules are free, but the sub-rotund posterior basal pinnules show no indication of a lateral lobe. The gradually-increasing union of the pinnules to each other on the pinnæ holding upper positions can be easily traced on this specimen, and finally the pinnæ assume the form of entire pinnules.

Another small portion of a primary pinna is given at fig. 2. In general character it is very similar to that just described, but shows the basal posterior pinnules situated in the angles caused by the union of the rachises of the secondary and primary pinnæ. This is also seen on the example given at fig. 1, but is not so constant a character there. The secondary pinnæ at the apex of the specimen given at fig. 2 terminate in long sharp points, and one which is almost perfect shows the rachis extending beyond the pinnules as a spine-like projection. This feature, however, is seen on two other specimens which are not figured.‡

None of our specimens shows the nervation very distinctly, but a few pinnules from a small example are enlarged two times at fig. 3, Pl. CXLII, to show the nervation. The median vein lies in a little furrow from which the lateral veinlets depart at an acute angle and follow a straight course to the margin of the pinnule.

* *Diplothmema Sauveuri* Stur, "Carbon-Flora d. Schatzlarer Schichten" (*loc. cit.*), pl. xxiv, fig. 2.

† *Loc. cit.*

‡ Kidston Collection, Nos. 3724 and 5855.

Except perhaps those at the base of the pinnule, they divide only once, but the basal ones may divide two times.

Mariopteris Sauveuri Brongniart sp. has for many years been usually regarded as a variety or form of *Mariopteris muricata* Schlotheim sp., but the evidence for this does not appear to be at all satisfactory. The differences between the two plants are very great, and the link which has been employed to connect them is *Mariopteris nervosa* Brongniart sp., but to this should also be restored, I think, the original specific rank accorded to it by BRONGNIART.

Mariopteris Sauveuri differs from *Mariopteris nervosa* Brongniart sp. in its pinnules being always obtuse, entire, seldom much longer than broad, and always united to each other except in the case of the posterior basal pinnule, which sometimes (though very rarely) is free. On none of our specimens has this basal pinnule shown a lobe on its posterior margin, though a blunt basal lobe is shown on some of the posterior basal pinnules on specimens figured by STUR.*

In *Mariopteris nervosa* Brongniart sp., on the other hand, the pinnules are longer in proportion to their width, more or less distinctly triangular in outline, taper regularly from the base upwards, and terminate in a point. They also have occasionally a few blunt teeth. Even in the forms *macrophylla* and *microphylla* of *Mariopteris nervosa*, as figured by BRONGNIART, where the pinnules are much united to each other, this distinction holds good. But further, in *Mariopteris nervosa* the posterior basal pinnule and frequently the anterior basal pinnule, almost invariably show a prominent basal lobe on their distal margin, and the two species could only be confused when one is dealing with very fragmentary and imperfect specimens.

Distribution.—Mariopteris Sauveuri Brongniart sp. is rare in Britain. It has been observed in the Staffordian Series, where, however, only a single specimen has as yet been discovered. Though more frequent in the Westphalian Series, it has only been obtained from four localities.

STAFFORDIAN SERIES.

CUMBERLAND COALFIELD.

BLACKBAND GROUP.

Horizon: ?. *Locality:* Whitehaven Brickworks, Low Road, Whitehaven (Collection of Geological Survey, London).

WESTPHALIAN SERIES.

CUMBERLAND COALFIELD.

Horizon: "Whitehaven Sandstones." *Locality:* Dingle, 500 yards W.S.W. of Moorside Colliery, Arlecdon (Collection of Geological Survey, London).

* *Loc. cit.*, pl. xxiv, figs. 2 and 4.

YORKSHIRE COALFIELD.

Horizon: Shale over Oaks Rock. *Locality:* Micklethwaite's Brickyard, Stairfoot, near Barnsley (W. HEMINGWAY).

Horizon: Shafton Coal. *Locality:* Brierley Colliery, Brierley, near Barnsley (W. BARKER).

Horizon: Seventy-five yards above Stanley Main Coal. *Locality:* Near Wakefield (J. GERRARD).

Mariopteris hirta Stur sp.

Plate CXLI, figs. 1, 1*a*; Plate CXLIII, fig. 4; Plate CXLIV, figs. 2, 2*a*.

1885. *Diplothmema hirtum* Stur, "Carbon-Flora d. Schatzlarer Schichten" (*loc. cit.*), p. 372, pl. xxxiv, fig. 1.

1886. *Mariopteris muricata* var. *hirta* Zeiller, "Flore foss. bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 182, pl. xx, figs. 4, 4*a*.

Description.—Petiole naked, at least 11·5 cm. in length and densely apiculate, with a few short transversely-elongated bars, dividing at its apex into two arms. These two arms, about 1·5 cm. in length and 5 mm. in breadth at the base, whose surface is apiculate and has a few scattered transverse bars, again dichotomize and the four resulting branches form the rachises of the four primary pinnæ of the frond. Primary pinnæ appear to be deltoid, rachis straight, apiculate, with a few obscure transverse bars, straight, and attaining a width at about 5 mm. Secondary pinnæ alternate, lanceolate, free, those at the base within the fork generally shorter than those on the outer side. The pinnæ terminate in a spine-like extension of the rachis. Pinnules alternate, slightly oblique to rachis, sessile, oval, obtuse, or contracted at apex into a point, free or more commonly slightly united at base; basal posterior and anterior pinnule have a basal lobe on their posterior margin, other pinnules almost invariably entire, all attached by a broad uncontracted base to the rachis.

Nervation immersed, and usually indistinctly seen. Median vein straight or slightly decurrent, lateral veinlets depart at an acute angle and take an upright, almost straight course to the margin of the pinnule. In the larger pinnules, the lower veinlets may dichotomize twice, or only the upper arm of the fork be divided, while the uppermost veinlets only once dichotomize. In the smaller pinnules the veinlets are generally divided only once.

Remarks.—The greater portion of a frond, showing its ramification, is given natural size on Pl. CXLI, fig. 1. The petiole, though incomplete at its lower end, is 7 mm. in breadth. It is very densely apiculate and has rather obscure transversely-elongated bars, as seen on the enlarged portion at fig. 1*a*. The petiole dichotomizes at its apex and the two arms separate at an angle of about 90°, dividing the frond into two sections. These arms again divide, and the resulting branches form the rachises of the four primary pinnæ of the frond. Only one of the primary pinnæ shows its termination, the lower one on the left, but is not shown on the figure. The lower primary pinnæ are smaller than the other two and, contracting rather suddenly near the apex, end in a sharp point. Their form must have been deltoid. As the two upper primary pinnæ exhibit only their lower portion, their form is not known, though probably it was similar to that of the lower primary pinnæ. All the pinnæ contract slightly at the base.

The secondary pinnæ are free; those on the lower primary pinnæ within the angle are shorter than those on the outer side. On the two upper primary pinnæ they seem to be of about equal size on both sides of the rachis. On the lower portion of the basal secondary pinnæ the pinnules are free, but towards the apex and on the upper secondary pinnæ they are slightly united to each other. The pinnules are placed obliquely to the rachis, are shortly-oblong, with blunt rounded apices or, more usually, are slightly contracted in their upper portion and end in a point. They are attached by the whole width of their uncontracted base. The basal anterior and posterior pinnules have a lateral lobe on the posterior margin, that on the posterior pinnule being larger than the lobe on the anterior one. On all the other pinnules on this specimen the lateral lobe is absent and their margins are entire.

On the lowest secondary pinna of the upper primary pinna of the right-hand section of the frond, the basal posterior pinnule is replaced by a small pinna bearing four lateral and a terminal lobe, comparable to the pinnæ on the inner side of the other arm of the section.

A small specimen with sharp-pointed pinnules is given natural size on Pl. CXLIV, fig. 2. It shows the terminations of some secondary pinnæ and the nervation of the pinnules. The rachis extends beyond the pinna as a spine-like point. All the terminations of the pinnæ of *Mariopteris hirta* that I have seen end in this manner. A pinna of this specimen is enlarged two times at fig. 2*a*, to show more clearly its spine-like termination and the nervation, which is seldom exhibited distinctly on account of its being immersed in the tissue of the pinnule. In the small pinnules on this specimen the lateral veinlets are usually divided only once.

On the upper part of the secondary pinna given enlarged two times at fig. 4, Pl. CXLIII, pinnules with obtuse and pointed apices are seen. The specimen also shows the rachis extending beyond the pinnules in the form of a spine-like projection, but with a very narrow margin of limb on each side. Sometimes this narrow border appears to be absent and the spine formed by the rachis alone.

Stur describes the surface of the pinnules as being hirsute, but Zeiller has pointed out that this character is not always observable, since he found the hirsute surface shown at some places on the specimen he described, but not at others. It is only in exceptional cases that the small hairs could be preserved. Small hairs are also known to be present on the surface of the pinnules of *Mariopteris muricata* * and *Mariopteris nervosa* (*ante*, p. 603), but I have failed to observe them on specimens preserved in ordinary Carboniferous shales as incrustations. They were probably

* See *ante*, p. 594, and *Mariopteris nervosa* (*ante*, p. 607).

very fugaceous and may have fallen off naturally or adhered to the other surface of the rock when the stone containing them was broken open.

The nearest ally to *Mariopteris hirta* Stur sp. is one or other of the forms of *Mariopteris nervosa* var. *elongata* Brongniart,* but in *Mariopteris hirta* the pinnules are broader, have convex sides, and are of almost equal width for about half their length before narrowing into a blunt point. In *Mariopteris nervosa*, however (with only one of the forms of which is it likely to be mistaken), the pinnules are longer in proportion to their width, contract from the base upwards, and have slightly concave sides. A comparison of the specimen given on Pl. CXLI with the figures of *Mariopteris nervosa* seen on Pl. CXLIII, figs. 1, 1*a*–*b*, will show these differences between the two species. In such forms of *Mariopteris nervosa* as that seen on Pl. CXL, figs. 1, 1*a*, even where there is a slight convexity on the sides of the pinnules, the tapering of the pinnules from the base upwards, and greater length proportionally to their width, will enable the two plants to be distinguished.

Distribution.—*Mariopteris hirta* Stur sp. is very rare and has been recorded only from the Westphalian Series.

WESTPHALIAN SERIES.

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Localities:* Crigglestone Colliery, Crigglestone (W. Hemingway); East Gawber Colliery, near Barnsley (W. Hemingway).

South Wales Coalfield.

Horizon: Pentre Seam. *Locality:* Trane Colliery, Gilfach Goch, Glamorganshire (D. Davies).

Mariopteris lobatifolia Kidston n. sp.

Plate CXL, figs. 3, 3*a*.

Description.—Ramification of frond imperfectly known. Penultimate pinnæ broadly lanceolate or deltoid, rachis straight, 3·5 mm. in breadth towards lower end and bearing numerous narrow, transversely-elongated, short ridges. Ultimate pinnæ slightly oblique to rachis, alternate, linear-lanceolate, free, rachis straight, of almost equal width for about three-quarters of their length, then gradually narrowing and ending in an obtuse terminal lobe. Pinnules alternate, oblong or sub-triangular, obtuse, free or slightly united to each other on the upper pinnæ. The pinnules on the lower-situated pinnæ have a more or less prominent lateral obtuse lobe at their base on the posterior margin. As the pinnules are traced upwards, the lateral lobe gradually becomes less and less and finally disappears. The higher-situated pinnules are short-oblong or sub-triangular, with entire or feebly sinuous margins. All

* "Hist. des végét. foss.," p. 297, pl. xciv.

the pinnules are more or less obtuse at apex, very slightly oblique to rachis, and attached by the whole of their uncontracted base. The basal pinnule on the posterior side is sometimes formed of two almost equal-sized lobes, and is situated in the angle formed by the union of the rachises of the ultimate and penultimate pinnæ.

Nervation immersed. Median vein thick, almost invariably straight, and only rarely showing a very slight decurrence, extending to near the apex of the pinnule, where it divides into two arms; lateral veinlets arcuate, somewhat distant, dichotomizing a short distance above their base; in the lower veinlets the upper arm of the fork usually again divides.

Remarks.—The only specimen of *Mariopteris lobatifolia* that I have seen was given to me by the late George Wild, of Oldham, by whom it was collected. It is seen natural size on Pl. CXL, fig. 3, and shows portions of four penultimate (? primary) pinnæ, the more perfect of which occupies the centre of the figure. The rachis of the penultimate pinnæ has numerous very short transversely-elongated ridges, but frequently these are so short that they appear as slightly elongate papillæ (fig. 3*a*). The rachises of the ultimate pinnæ seem to be smooth.

For the greater portion of their length, the ultimate (? secondary) pinnæ are of almost equal width, then they gradually taper and end in a blunt terminal lobe.

The ultimate pinnæ on the penultimate pinna seen in the centre of the figure are of very unequal length on the two sides of the rachis. On the right side towards the upper end they suddenly become much shorter than on the other side, and the pinnules on these short pinnæ become more and more united to each other as the pinnæ are traced upwards, and on the uppermost apical region they assumed the form of narrow, triangular, free pinnules with usually a straight median vein. The corresponding pinnæ on the opposite side of the rachis are not shown on the upper part of the penultimate pinnæ, but where they are present the pinnules are not united to each other or are only very slightly united among themselves.

The basal posterior oblong pinnule has a very prominent obtuse lobe which projects almost at a right angle. More rarely this lobe is of almost equal size to the other portion of the pinnule. The succeeding pinnules on both sides of the rachis, as well as the basal pinnule on the anterior side, have each a basal lobe, but as the pinnules are followed upwards the basal lobe becomes less and less prominent, and the pinnules assume a more triangular form with slightly sinuous or entire margins and obtuse apices. Except on the uppermost pinnæ already described, the pinnules are free till near the extreme tip of the pinnæ.

The species with which *Mariopteris lobatifolia* is most likely to be mistaken is the *Mariopteris nervosa* Brongniart sp., but the pinnules on the latter species are almost invariably united to each other at the base, even on the ultimate pinnæ holding basal positions; the lateral veinlets are closer and the apices of the pinnules are more acute. In *Mariopteris nervosa* only the basal posterior pinnule and (more rarely) the basal anterior pinnule have a lobe at the base of their distal margin, while in *Mariopteris lobatifolia* the succeeding pinnules on both sides of the rachis have a lateral basal lobe. These differences at once distinguish the two species.

From *Mariopteris Sauveuri* Brongniart sp. *Mariopteris lobatifolia* is easily separated by its free pinnules with the prominent lateral lobe. On *Mariopteris Sauveuri* a lateral lobe, when present, is usually feebly developed and only on the basal pinnule.

Distribution.—Of *Mariopteris lobatifolia* only a single specimen, from the Westphalian Series, has been found.

WESTPHALIAN SERIES.

Lancashire Coalfield.

Horizon: Roof of Peacock Coal. *Locality:* Bardsley Colliery, Ashton-under-Lyne (G. Wild).

Mariopteris acuta Brongniart sp.

Plate CXXXIX, figs. 1, 1*a*; Plate CL, figs. 2, 2*a*; Plate CLI, figs. 4, 4*a*, 5, 5*a*; text-fig. 90.

1831. *Sphenopteris acuta* Brongniart, "Hist. des végét. foss.," p. 207, pl. lvii, fig. 5 (named *Sphenopteris acutifolia* in Plate).
1833. *Sphenopteris acuta* Sternberg, "Essai flore monde prim," vol. i, fasc. 5–6, p. 64.
1835. Cf. *Sphenopteris acuta* Gutbier, "Abdrücke u. Verstein. d. Zwickauer Schwarzkohl.," p. 42, pl. iv, figs. 15, 16.
1845. *Sphenopteris acuta* Unger, "Synop. plant. foss.," p. 67. (*Refs. in part.*)
1848. *Sphenopteris acuta* Bronn, "Index palaeont.," p. 1167. (*Refs. in part.*)
1850. *Sphenopteris acuta* Unger, "Genera et species," p. 123. (*Refs. in part.*)
1869. *Sphenopteris acuta* Roehl, "Foss. Flora d. Steink. Form. Westph.," *Palaeontographica*, Band xviii, p. 59, pl. xxxi, fig. 3. (*Refs. in part.*)
1869. *Sphenopteris* (*Aneim.*) *acuta* Schimper, "Traité de paléont. véget.," vol. i, p. 400.
1836. *Aspidites acutus* Göppert, "Syst. fil. foss.," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 356.
1877. *Diplothmema acutum* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 230 (125).
1885. Cf. *Diplothmema acutum* Stur (*pars*), "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 364, pl. xxvi, figs. 3 and 5 (*non* pl. lxv, fig. 1).
1879. *Mariopteris acuta* Zeiller, "Note sur le genre *Mariopteris*," *Bull. Soc. géol. France*, ser. 3, vol. vii, p. 98.
1899. *Mariopteris acuta* Zeiller, "Flore foss. bassin houil. d'Héraclée," *Mém. Soc. géol. France*, xxi, p. 31, pl. ii, fig. 16.
1910. *Mariopteris acuta* Deltenre in Renier, "Documents pour l'étude de la paléont. du terr. houil.," pl. lxxxv.
1912. *Mariopteris acuta* Huth, "Fossile Gattung *Mariopteris*," Inaugural-Dissertation (Berlin), p. 51, figs. 14, 15.
1912. *Mariopteris acuta* Huth in Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8, No. 144, figs. 1, 2.
1914. *Mariopteris acuta* Bureau, "Bassin de la Basse Loire," fasc. 2, "Flores fossiles," *Études Gîtes Min. France*, p. 280, pl. xxiv, *bis* figs. 4, 4A, 4B, 5, 5A.
1915. *Mariopteris acuta* Jongmans and Gothan, "Palaeobot.-strat. Studien," *Archiv für Lagerstättenforschung*, No. 18 (*K. preuss. geol. Landesanst.*), p. 176, pl. v, fig. 6.
1923. *Mariopteris acuta* Gothan in Gürich, "Leitfossilien," Lief. 3, p. 40, pl. vii, fig. 1.

1832. *Pecopteris muricata* Brongniart (*pars*), *op. cit.*, pl. xcvii.
1901. *Mariopteris muricata* Kidston (*non* Schlotheim), "The Flora of the Carboniferous Period," *Proc. Yorks. Geol. and Polytech. Soc.*, vol. xiv, pt. 2, p. 195, pl. xxxii, figs. 1, 1*a*.
1855. *Sphenopteris acutifolia* Ettingshausen (*non* Brongniart), "Steinkohlflora v. Radnitz," *Abhandl. k. k. geol. Reichsanst.*, Band ii, Abth. 3, p. 39 (*non* pl. xiv, fig. 2).
1877. *Sphenopteris macilenta var.* Lebour (*non* Lindley and Hutton), "Illustrations of Fossil Plants," p. 39, pl. xix.
1883. *Sphenopteris Schillingsii* Achepohl (*non* Andrae), "Niederrheinisch-Westfälische Steinkohlengebirge," Lief. 10, Ergänzungsblatt 1, fig. 40.

Description.—Stem attaining a width of 1·5 cm. or more, with numerous short transverse bars on outer surface.

Petiole with a breadth of at least 7 mm., with very fine striations and transverse bars, dichotomizing at apex and dividing the frond into two sections. Each of these arms again divides at a wide angle, and the resulting branches form the rachises of the four primary pinnæ which compose the frond. Primary pinnæ broadly lanceolate or deltoid, rachis very slightly flexuous, with two ridges passing up its surface and numerous small transverse bars. Secondary pinnæ alternate, linear-lanceolate to broadly lanceolate, rachis straight, canaliculate on upper surface, and sometimes extending beyond the pinnules as a spine-like point. Pinnules alternate, of an oblong or sub-triangular contour; those situated on the lower secondary pinnæ contracted at base and of sphenopteroid form, but on the upper situated pinnæ the width of attachment gradually increases and the pinnules become pecopteroid and more or less united to each other at the apex of the pinnæ. The sphenopteroid pinnules have 2–3 pairs of prominent forwardly-directed, obtusely-pointed lobes with convex margins, and sometimes a slight lateral tooth; the basal anterior and posterior pinnule have a large bifid lobe on their distal margin, of which that on the posterior pinnule is the larger. The terminal pinnule has usually a few obtusely-pointed teeth, and sometimes the median vein extends as a spine-like point. On the basal portion of the primary pinnæ these sphenopteroid pinnules sometimes become elongate, the lobes become separate, and the structure assumes the form of tertiary pinnæ. The more oblong pinnules have two or three pairs of upward-directed, lateral saw-like teeth, and are sphenopteroid at the base of the pinnæ, but as traced upwards gradually assume the pecopteroid form and become united to each other.

Nervation immersed and frequently not distinctly seen. In the sub-triangular sphenopteroid pinnules the median vein gives off a lateral veinlet to each lobe, where it divides two or three times. The lobe may have from ten to twelve ultimate veinlets at the margin. In the oblong pecopteroid pinnules with saw-like teeth each lobe has from three to five ultimate veinlets.

Remarks.—The more divided form of the frond with sphenopteroid pinnules is shown natural size on Pl. CL, fig. 2. Passing up the middle of the figure is part of the stem. It is 1·5 cm. in breadth at the base and bears many short transverse ridges. Towards the base of the fragment it gives off a petiole, 7 mm. in breadth, which also bears numerous short transverse bars. Part of what I regard as a primary pinna is lying across the specimen. Its rachis is 3 mm. in breadth and slightly flexuous. Two ridges pass up its surface; these probably represent the vascular strand, since they seem to give off lateral branches to the secondary pinnæ. The rachises of the secondary pinnæ are straight and canaliculate on their upper surface. On this specimen the pinnules are contracted at base and are of the sphenopteroid type. They are large, some being over 1·5 cm. in length, and are attached to the rachis by a thick footstalk. They are usually formed of four lateral lobes and one terminal lobe. The lobes have convex margins, are more or less oblong-oval, directed forwards, not spreading outwards, and end in an obtuse point. The terminal lobe is ovate, and has a few small teeth, and the median vein sometimes projects as a spine-like point. The basal anterior and posterior pinnules have a prominent lobe on the distal margin. These structures, which I have described as pinnules, might equally well be regarded as tertiary pinnæ with simple, more or less united pinnules, for at the base of the figure, immediately above the petiole springing from the stem, part of a secondary pinna is seen. Here the median vein of the "pinnules" has become elongated, the segments are free, and the "pinnules" of the secondary pinnæ on the upper portion of the specimen have assumed the form of veritable tertiary pinnæ, with upper simple and basal bilobed pinnules.

A pinnule from this specimen is enlarged three and a half times at fig. 2*a*, to show the nervation. Its surface has a fine papillose appearance, caused by the epidermal cells, which are seen to be arranged in parallel rows. A single vein enters each segment, and through repeated division supplies the basal lobe with about a dozen ultimate veinlets, but the upper lobes have a smaller number.

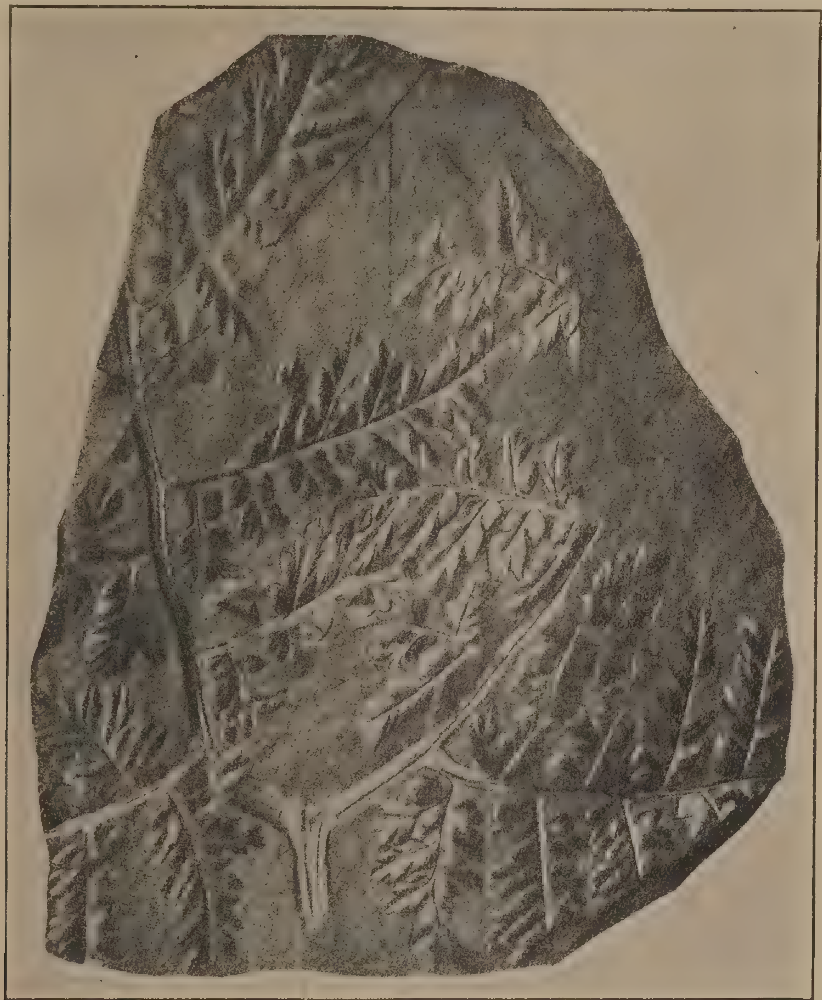
On the specimen given natural size on Pl. CLI, fig. 5, the secondary pinnæ are slightly contracted at the base and usually end in a spine-like extension of the rachis. The pinnules are oblong to broadly lanceolate, and their margins bear saw-like, forward-directed teeth. The basal anterior and posterior pinnules are sphenopteroid in form and have a prominent lobe on their distal margin. As the pinnules are followed upwards, their point of attachment to the rachis becomes gradually broader till at the apex of the pinnæ they have assumed the pecopteroid form.

A very small fragment, probably from the apical portion of a primary pinna, is given natural size at fig. 4, Pl. CLI, and three pinnules are enlarged two times at fig. 4*a*. They are oblong, have three forward-directed, saw-like teeth on each margin, are slightly oblique to rachis, and are attached by a wide base.

That the fronds of *Mariopteris acuta* sometimes attained a large size is shown by the fragments of primary pinnæ given natural size on Pl. CXXXIX, fig. 1.

The rachises are not very well preserved, but show the two longitudinal ridges. The secondary pinnæ are alternate, broadly lanceolate, with straight rachis, and the longest perfect one attains a length of 8 cm.

The pinnules are more or less lanceolate. Those holding lower positions on the pinnæ are contracted at the base, but those situated towards the apex have a gradually increasing width of attachment to the rachis. The basal anterior and posterior pinnules have a very large lateral lobe on their distal margin and a few obtusely-pointed lateral lobes. Some of the pinnules reach a length of fully 2 cm. and have a width of 5 mm., and usually have three pairs of forward-directed alternate lobes with rather obtuse points, but being gently incurved their apices may be



TEXT-FIG. 90.—*Mariopteris acuta* Brongniart sp. Specimen showing the ramification of the frond. Copied from HUTH.

slightly embedded in the rock. They are very similar to the upper pinnule of BRONGNIART's enlarged figure.* One of them is enlarged two times at fig. 1*a*. When the pinnules are followed from the base to the apex of the pinna the lobes gradually disappear and the apical pinnules become entire. The only complete secondary pinna on this example terminates in a spine-like point. For this fine example, I am indebted to the kindness of Mr PATERSON.

To exemplify the ramification of the frond an illustration given by HUTH † is reproduced here at text-fig. 90.

* *Loc. cit.*, pl. lvii, fig. 5A.

† *Loc. cit.*, fig. 2.

The specimen described under the name of *Mariopteris acuta* by Zeiller in his "Flore fossile du bassin houiller de Valenciennes" (p. 164, pl. xviii, fig. 2), I refer to *Mariopteris muricata*. It seems to agree completely with the figure of *Filicites muricatus* given by Schlotheim in his "Flora der Vorwelt" (pl. xii, fig. 23).

The species with which *Mariopteris acuta* is most likely to be confused is the *Mariopteris muricata* Schlotheim sp., but in that species the lateral saw-like lobes or teeth are directed more outwards, not adpressed to the pinnule as in *Mariopteris acuta*, where also the pinnules are often long and narrow, a form not seen (so far as I am aware) in *Mariopteris muricata*. Moreover, in *Mariopteris muricata* one does not see triangular pinnules so distinctly segmented as those seen on the specimen of *Mariopteris acuta* given on Pl. CL, fig. 2. Careful attention to these points will enable the species to be distinguished.

Distribution.—*Mariopteris acuta* Brongniart sp. is not common in Britain, but has been found in the Westphalian Series and Lanarkian Series.

WESTPHALIAN SERIES.

Cumberland Coalfield.

Horizon: Strata between Bannock Coal and Six-quarter Coal. *Locality:* Wellington Pit, Whitehaven (Collection of Geological Survey, London).

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley, Yorkshire.

South Wales Coalfield.

Horizon: ?. *Locality:* Walton Hill, Little Haven, Pembrokeshire (Prof. O. T. Jones).

Devonshire.

Horizon: "Culm Measures" of North-west Devon. *Locality:* Robert's Quarry, East-the-Water, Bideford (Inkerman Rogers).

LANARKIAN SERIES.

Fifeshire Coalfield.

Horizon: Near base of Coal-bearing strata. *Locality:* Blairpoint, Dysart.

Lanarkshire Coalfield.

Horizon: ?. *Locality:* Tollcross, Glasgow (G. E. Paterson).

Mariopteris Beneckei Huth.

Plate CLII, figs. 4, 4*a*, 5, 5*a*; text-figs. 91 and 92.

1912. *Mariopteris Beneckei* Huth in Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," (*K. preuss. geol. Landesanst.*), Lief. 8, No. 151, figs. 1–7, ? fig. 8.
1912. *Mariopteris Beneckei* Huth, "Foss. Gattung *Mariopteris*," Inaugural-Dissertation (Berlin), p. 74, figs. 34–40.
1913. *Mariopteris* cf. *Beneckei* Gothan, "Oberschlesische Steinkohlenflora," Teil 1, *Abhandl. k. preuss. geol. Landesanst.*, N.F., Band lxxv, p. 101 (? pl. xxi, fig. 1).
1915. *Mariopteris* cf. *Beneckei* Jongmans and Gothan, "Palaeobot.-strat. Studien," *Archiv für Lagerstättenforschung*, No. 18 (*K. preuss. geol. Landesanst.*), p. 176 (? pl. vi, fig. 4).
1885. *Diplothmema acutum* Stur (*non* Brongniart) (*pars*), "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 364, pl. lxv, fig. 1. (*Excl. ref.*)

Description.—Frond of lax type of growth. Ramification not completely known. Petiole (or rachis of section) of frond naked, with two slightly separated straight or very slightly flexuous prominent longitudinal furrows, dichotomizing at apex and bearing numerous short, narrow, transversely-elongated ridges. The two arms of the fork separate at an angle of about 80° and form the rachises of the two resulting primary pinnæ. Rachis of primary pinnæ with two prominent longitudinal furrows, and bearing either bars similar to those on the petiole or scattered blunt apiculi. Secondary pinnæ alternate, broadly lanceolate or narrow-deltoid, touching laterally; rachis straight and bearing short, narrow, transversely-elongated ridges. Tertiary pinnæ alternate, lanceolate or narrow-deltoid, free, with a slightly obtuse or pointed terminal lobe; the larger pinnæ bear seven or more pairs of pinnules.

Pinnules are oblique to rachis and vary greatly in size and form. Some are oblong, with almost straight sides, rounded obtuse apex, and attached by all their base (pecopteroid); others are contracted at the base and attached by a broad footstalk (sphenopteroid), with acute apex and bearing a few forward-directed lateral lobes with acute or obtuse apices. The basal pinnule on the posterior side has usually a large lateral lobe on its posterior margin. Between these two types of pinnules intermediate forms occur. On the larger and lower-situated tertiary pinnæ the pinnules are free, except at the apex, where they become more or less united to each other. On the higher-placed tertiary pinnæ the pinnules are generally attached to the rachis by a broad base, entire, and more or less united to each other.

Nervation immersed and frequently not observable, but in the lower and "sphenopteroid" pinnules it consists of a flexuous median vein from which the lateral veinlets depart at an acute angle and dichotomize once or twice in the lateral lobes. In the pinnules of the "pecopteroid" type, the lateral veinlets appear to divide only once in their course to the margin.

Remarks.—Though the complete ramification of the frond of *Mariopteris Beneckei* is not known, it is probable that a dichotomy of the petiole took place at its apex and divided the frond into two sections (as in *Mariopteris muricata* Schlotheim sp.), but the most complete specimen yet described or figured shows only a portion of a naked petiole or rachis about 7 cm. in length and about 4 mm. in breadth, which divides at its apex into two arms. This specimen, which is reproduced at our text-fig. 91,* is here interpreted as representing one of the two sections of a *Mariopteris* frond showing the two primary pinnæ of which the section was composed.* On this assumption, the description given above is drawn up.

The few British specimens of *Mariopteris Beneckei* Huth that I have seen are all fragmentary; two of them are given on Pl. CLII, figs. 4 and 5. That seen at fig. 4 represents an example with the "sphenopteroid" form of pinnule. The pinnules on this specimen are distant, free, and more or less contracted at the base. This is especially well seen at the bottom of the figure. The basal anterior and posterior pinnules have each a large lobe on their posterior margin, a feature very characteristic of the genus *Mariopteris*, though on the upper pinnule it is sometimes absent. The lobes on the succeeding pinnules become less and less pronounced, and the area of attachment of the pinnules to the rachis increases as they are traced upwards, and immediately below the terminal lobe they are almost entire.

The coaly matter into which the epidermis has been converted has almost all fallen from the rachises of the secondary pinnæ shown on the specimen, but on the rachis at the base of the figure a small portion still adheres and exhibits the small transversely-elongated ridges. These ridges can be seen on the enlargement of the secondary rachis, to which a tertiary pinna is attached at fig. 4*a*.

The lobes of the pinnules, especially on the larger ones at the basal end of the pinnæ, are usually very obtuse, as are sometimes the other lateral lobes, but very frequently they have sharp points and the apex of the pinnule may also be acute or obtuse. On this specimen the nervation is not shown.

A small specimen, which is probably the upper end of a secondary pinna, is given natural size on fig. 5, Pl. CLII. The tertiary pinnæ have partially assumed the form of pinnules, though really they are pinnæ composed of simple pinnules of the pecopteroid type, more or less united to each other. Some have a few small teeth, which are well seen on the enlargement at fig. 5*a*. The surface of the pinnules is beautifully preserved and exhibits a very fine striated appearance, evidently caused by the rows of the epidermal cells. The nervation is very indistinctly seen, being immersed in the tissue of the pinnule.

On the specimen figured by Huth, whose illustration is copied at text-fig. 91, the pinnules are mostly of the "pecopteroid" type, especially on its upper part, but not so distinctly as on the example figured in the "Abbild. u. Beschreib. foss. Pflanzen-Reste" (No. 151, fig. 1), of which a tertiary pinna is reproduced at our text-fig. 92.

In the "sphenopteroid" form of pinnule the slightly flexuous median vein

* See Huth, "Foss. Gattung *Mariopteris*," fig. 38; or Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," No. 151, fig. 5.

gives off lateral veinlets which depart at a fairly acute angle. One goes to each lobe of the pinnule, where it dichotomizes at an acute angle once or twice, according to the size of the lobe. In only a few of the pinnules of one of our specimens is the nervation observable.

The fig. 4 of HUTH * shows a form of pinnule with many small prominent marginal

TEXT-FIG. 91.—*Mariopteris Beneckei* Huth. One of the two sections of the frond showing two primary pinnæ. Natural size. Copied from HUTH.

teeth, and though it possibly belongs to *Mariopteris Beneckei,* it is not a typical example of the species.

The fine specimen figured by STUR † under the name of *Diplothmema acutum* (*non* Brongniart) is clearly referable to *Mariopteris Beneckei,* as pointed out by HUTH.

* " Abbild. u. Beschreib. foss. Pflanzen-Reste."

† *Loc. cit.*, pl. lxv, fig. 1.

The species with which *Mariopteris Beneckei* is most likely to be and has been confused is *Mariopteris latifolia* Brongniart sp., but the two species have a very distinct type of growth. In *Mariopteris latifolia* Brongniart sp. the pinnæ and the pinnules are closer and the frond has a solid type of growth.

Text-fig. 92.—*Mariopteris Beneckei* Huth. Tertiary pinna enlarged two times to show "pecopteroid" pinnules and their nervation. Enlarged two times. After Huth.

In *Mariopteris Beneckei*, on the other hand, the frond has a lax type of growth, on account of the pinnæ and pinnules being more distant. This species is also much more variable in the form of its pinnules. The difficulty of distinguishing these two species arises chiefly when only small or imperfectly-preserved fragments are available. With well-preserved material they are easily separated.

From *Mariopteris neglecta* Huth,* *Mariopteris Beneckei* is also easily distinguished by its much more lax growth and its more distinct pinnules.

Distribution.—Though *Mariopteris Beneckei* Huth has been recorded from four coalfields, it is a rare British species. I have not seen more than a dozen specimens, all of which came from the Westphalian Series.

WESTPHALIAN SERIES.

Burnley Coalfield.

Horizon: Arley Mine. *Locality:* Brickworks, Hibson Road, at Marsden Height, Nelson (P. Whalley).

Cumberland Coalfield.

Horizon: ?. *Locality:* Old Brickworks under cliff by Mineral Railway from Whitehaven to Parton (Collection of Geological Survey, London).

Northumberland and Durham Coalfield.

Horizon: Crow Coal. *Locality:* Phœnix Brickworks, Crawcrook, Ryton, County Durham (W. Eltringham).

Horizon: Three-quarter Coal. *Locality:* Chopwell, 2½ miles north-east of Ebchester, County Durham (P. Charlton).

Yorkshire Coalfield.

Horizon: Below Black Bed Coal. *Locality:* Dolly Lane, Leeds (J. H. Bond).

Horizon: 46½ feet above Barnsley Coal. *Locality:* Brodsworth Colliery Sinking, 4 miles north-west of Doncaster (H. Culpin).

Horizon: White Rake Bed. *Locality:* Low Moor, near Bradford.

* Huth in Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8, No. 148, figs. 1, 2, 1912.

Mariopteris nobilis Achepohl sp.

Plate CXLIX, figs. 4, 4*a*, 5; Plate CLIII, fig. 8; text-fig. 93.

1883. *Sphenopteris nobilis* Achepohl, "Niederrheinisch-Westfälische Steinkohlengebirge," Lief. 10, Ergänzungsblatt 3, fig. 5, and Explan. to plate.

Remarks.—This species was founded by ACHEPOHL on a single fragment, which is reproduced natural size at text-fig. 93. It shows portion of a linear-lanceolate penultimate pinna about 6 cm. in length and 2·5 cm. in breadth at the base, which springs from a rachis 3 mm. in breadth. The apical portion of the pinna is absent. The fragment shows alternate, deltoid, ultimate pinnæ 1·50 cm. in length, which touch each other laterally but do not overlap. Their rachis is straight and bears two or three pairs of alternate pinnules and a terminal lobe. On the two lowest-situated ultimate pinnæ the basal posterior pinnule bears a few small lobes and a large basal lobe on its distal margin. On the higher-situated pinnæ the basal posterior and anterior pinnule are only slightly larger than the succeeding pinnules, and the posterior pinnule shows a small lobe on its distal margin. The nervation is not clearly indicated on the figure.

TEXT-FIG. 93. *Mariopteris nobilis* Achepohl sp. Copied from ACHEPOHL.

Two small fragments of *Mariopteris nobilis* Achepohl sp. are given on Pl. CXLIX, figs. 4 and 5. That at fig. 4 is shown natural size and is enlarged two times at fig. 4*a*. This small piece is remarkably like the specimen figured by ACHEPOHL and corresponds with the upper two-thirds of his figure. The rachis is straight, and gives off alternate, deltoid, ultimate pinnæ which bear two pairs of alternate pinnules and a terminal lobe. The upper-situated pinnæ become less deltoid than those at the base, but are of about the same length. The basal posterior pinnule has a broadly oval contour, is larger than the others, and has a prominent lateral lobe on its distal margin which itself has a small lobe that may be either obtuse or obtusely pointed; the other portion of the pinnule bears a few small blunt lobes. The basal pinnule on the anterior side has also a slight lobe on its distal margin. The upper pair of pinnules are obovate and slightly united to the base of the obovate terminal pinnule.

The pinnules on the upper ultimate pinnæ are of a similar form, but the lateral lobe on the basal pinnules is feebly developed.

Our other small fragment of *Mariopteris nobilis* Achepohl sp. is seen enlarged two times at fig. 5. The rachis is straight and has a few short transverse bars on its surface. The ultimate pinnæ are much reduced in size on the right side of the rachis, are deltoid and shorter than those on the opposite side, which are more linear. The lobes and the apex of the pinnules are generally more obtuse or obtusely pointed than is shown on ACHEPOHL's figure, but in every other character our specimens agree. The difference, however, can scarcely be regarded as of specific importance.

The nervation is fairly well exhibited on our two small fragments. The median vein is thick and decurrent. The lateral veinlets depart at an acute angle and divide once or twice in their course to the margin.

Fig. 5 shows the upper surface of the pinnules, which appears to be smooth, while fig. 4 exhibits their dorsal surface bearing many scattered bristle-like adpressed hairs, especially on the backs of the veins. These are shown on Pl. CLIII, fig. 8, enlarged sixteen times.

HUTH has expressed the view that *Mariopteris nobilis* Achepohl sp. may perhaps belong to *Mariopteris acuta* Brongniart sp.,* but if I am correct in my interpretation of ACHEPOHL's species, then it is quite distinct from *Mariopteris acuta.*

In his "Fossil Flora of the Lower Coal Measures of Missouri," WHITE unites *Mariopteris nobilis* Achepohl with *Mariopteris sphenopteroides* Lesquereux sp.,† and as this species is figured by him the two plants have a great similarity, but the ultimate pinnæ of WHITE's plant are much longer and more linear.

The original specimen of *Mariopteris nobilis* Achepohl was far too fragmentary for the foundation of a new species, but unfortunately that course was adopted. As our small fragments seem to agree perfectly with ACHEPOHL's plant they are described under his name. The specific value of the species must, however, remain undecided until more perfect specimens are obtained.

Distribution.—Very rare, and known in Britain from only one locality in the Staffordian Series.

STAFFORDIAN SERIES.

SOUTH WALES COALFIELD.

BLACKBAND GROUP.

Horizon: No. 3 Rhondda Seam. *Locality:* Glamorgan Colliery, Gilfach Goch, Glamorganshire (D. DAVIES).

Mariopteris Daviesi Kidston n. sp.

Plate CXLVI, figs. 1, 1*a*, 2, 3.

1882. *Floropteris* Achepohl, "Niederrheinisch-Westfälische Steinkohlengebirge," Lief. 5, p. 91 (pl. xxix, fig. 3 ?), Ergänzungsblatt 4, fig. 26.

Description.—Frond of considerable size. The two arms of the petiole that dichotomize to form the rachises of the four primary pinnæ of the frond are 8 mm. in

* HUTH in POTONIÉ, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8, No. 142, p. 2, 1912; also HUTH, "Foss. Gattung *Mariopteris*," Inaugural-Dissertation (Berlin), p. 30, 1912.

† Page 31, pl. ix, figs. 1, 2; pl. x.

breadth, and have fine longitudinal striæ and narrow transversely-elongated ridges about 1 mm. in length. The resulting rachises of the primary pinnæ separate at almost right angles and are 5 mm. in breadth at the base, with numerous narrow transversely-elongated ridges rather less than 1 mm. in length. Secondary pinnæ alternate, lanceolate, touching or overlapping laterally; rachis broad, straight, with fine striations and numerous short transversely-elongated ridges. Tertiary pinnæ alternate, lanceolate, tapering gradually from the base and terminating in a point.

Pinnules alternate, with convex margins, narrow-triangular, attached by a broad base, attaining a length of 1·5 cm., free or slightly decurrent, and more or less united to each other, with forward-directed, pointed lobes, or entire, according to the position of the pinnæ on the frond that bears them. Those on the posterior side are usually slightly larger than those on the anterior side of the pinnæ. The basal posterior pinnule on the lower-situated tertiary pinnæ has a prominent lobe on its distal margin, and occasionally the anterior basal pinnule has one also, but not so much developed. On the upper tertiary pinnæ, a basal lobe on the distal margin of the posterior and anterior pinnule is not developed.

Nervation immersed and not very distinctly seen. The median vein extends to near the apex, where it divides into two arms. The lateral veinlets depart at an acute angle, dichotomize once or twice and pursue an upward, almost straight course to the margin of the pinnule.

Remarks.—Three specimens of *Mariopteris Daviesi* are given natural size on Pl. CXLVI, figs. 1–3. That seen at fig. 3 is interpreted as showing part of one of the two arms of the dichotomy of the petiole, divided into two arms that go to form two primary rachises, which compose one of the sections of the frond. On this assumption the above description has been written. They are about 3 mm. in breadth at the base and bear characteristic small elongated ridges. Two secondary pinnæ are seen departing at almost right angles to the primary rachis. The rachises of the two secondary pinnæ seen on the specimen are about 2 mm. in breadth and also bear small bars. The tertiary pinnæ are alternate, linear-lanceolate, slightly oblique, and have a straight thick rachis with a gutter-like furrow on its upper surface. The alternate pinnules are oblique, of a narrow triangular form, decurrent, with recurved margins and, except at the extreme base of the pinnæ, more or less united to each other, and attached by their whole width to the rachis. The basal pair are usually slightly contracted at the base and have a more or less distinct basal lobe on their distal margin, which is not well seen on the figure on account of its being incurved. The pinnules are somewhat convex at the margin and bear a few pointed teeth, whose apices seem to be frequently embedded in the matrix.

A portion of a primary pinna is given at fig. 1. None of the secondary pinnæ is perfect, but the one at the base must have been at least 15 cm. in length. The tertiary pinnæ are alternate, lanceolate, contracting gradually from the base to the apex and terminating in a point. On the tertiary pinnæ, on the basal part of the secondary pinnæ seen at the bottom of the figure, the pinnules are mostly free, and only become united to each other near the apex of the pinnæ. The basal posterior and anterior pinnules, though in the latter to a slighter extent, have a lateral lobe on their distal margin. The pinnules on the basal pinnæ of this part of the specimen agree in form with those on the fragments of secondary pinnæ seen on fig. 3.

The pinnules on the tertiary pinnæ holding higher levels on the primary pinnæ become more and more united to each other, and eventually the pinnæ assume the form of pinnules. Thus the tertiary pinnæ seen at the upper left-hand corner of fig. 1 do not differ much in form from some of the pinnules seen at the base of the figure, except in being slightly larger. This specimen illustrates very well the gradual transition of pinnæ into pinnules, and the difficulty of sometimes drawing a definite line of separation between them.

Some tertiary pinnæ from the central secondary pinna of the specimen given at fig. 1 are enlarged two times at fig. 1*a*. The pinnules are triangular in form and are very slightly united to each other. The basal posterior pinnule has a prominent lateral lobe on its distal margin, but the marginal teeth on the other pinnules are less prominent and have entirely disappeared from the upper pinnules.

On the small specimen given natural size at fig. 2, the rachis of the secondary pinnæ is very broad, the tertiary pinnæ are elongate-triangular and terminate in a sharp point; the pinnules are united to each other for a distance of half their length or more, and the pinnæ have very much assumed the form of pinnules. It seems very probable that in *Mariopteris Daviesi* the apex of the pinnules and their marginal teeth had sharp points, and such can occasionally be observed, though usually they appear obtuse. This is probably due to the teeth being partially embedded in the matrix, through the margin of the pinnules and their apices being slightly reflexed.

Mariopteris Daviesi is a very distinct plant, and well-preserved specimens could not, I think, be mistaken for any other described species. Small fragments of secondary pinnæ from the apical region of the primary pinnæ, where the tertiary pinnæ have assumed the form of pinnules, have, however, a slight similarity to *Mariopteris acuta* Brongniart sp., but these pinnæ-pinnules have a more solid appearance than the pinnules of Brongniart's species.

I have much pleasure in naming this *Mariopteris* after Mr D. Davies, M.Sc., F.G.S., to whom I am much indebted for my knowledge of the fossil plants of the South Wales Coalfield.

Distribution.—*Mariopteris Daviesi* has been found only in the South Wales Coalfield, where, however, it has been recorded from the Radstockian, Staffordian, and Westphalian Series.

RADSTOCKIAN SERIES.

South Wales Coalfield.

FARRINGTON GROUP.

Horizon : No. 1 Llantwit Seam. *Locality :* Beddau, near Llantrisant, Glamorganshire (D. Davies).

Horizon : No. 3 Llantwit Seam. *Localities :* Cross Inn, near Llantrisant, Glamorganshire (D. Davies) ; Castellau, near Beddau, Glamorganshire (D. Davies).

STAFFORDIAN SERIES.

South Wales Coalfield.

NEWCASTLE-UNDER-LYME GROUP.

Horizon: Darranddu Seam. *Locality:* Mynachdy Colliery, Old Ynysybwl, near Pontypridd, Glamorganshire (D. Davies).

Blackband Group.

Horizon : No. 2 Rhondda Seam. *Locality :* Dinas Main Level, Gilfach Goch, Glamorganshire (D. Davies).

Horizon : No. 3 Rhondda Seam. *Locality :* Glamorgan Colliery, Gilfach Goch, Glamorganshire (D. Davies).

WESTPHALIAN SERIES.

South Wales Coalfield.

Horizon: Five-foot Seam. *Locality:* Britannic Colliery, Gilfach Goch, Glamorganshire (D. Davies).

Horizon : Pentre Seam. *Locality :* Trane Colliery, Gilfach Goch, Glamorganshire (D. Davies).

Horizon : Upper Yard Seam (= Bute Seam). *Locality :* Britannic Colliery, Gilfach Goch, Glamorganshire (D. Davies).

Mariopteris latifolia Brongniart sp.

Plate CXLIV, fig. 7 ; text-figs. 94, 95.

1828. *Sphenopteris latifolia* Brongniart, " Prodrome," p. 51.
1831. *Sphenopteris latifolia* Brongniart, " Hist. des végét. foss.," p. 205, pl. lvii, figs. 1–4. (*Excl.* syn. *Filicites muricatus.*)
1833. *Sphenopteris latifolia* Sternberg, " Essai flore monde prim.," fasc. 5–6, p. 63. (*Refs. in part.*)
1842. *Sphenopteris latifolia* Göppert, " Gatt. d. foss. Pflanzen," Lief. 3, 4, p. 74, pl. xiv, figs. 5, 6.
1845. *Sphenopteris latifolia* Unger, " Synop. plant. foss.," p. 67. (*Excl. ref.* L. and H.)
1848. *Sphenopteris latifolia* Bronn, " Index palaeont.," p. 1169. (*Ref. in part.*)
1850. *Sphenopteris latifolia* Unger, " Genera et species plant. foss.," p. 123. (*Excl. ref.* L. and H.)

1869. *Sphenopteris latifolia* Schimper, "Traité de paléont. végét.," vol. i, p. 401.
1869. *Sphenopteris latifolia* Roehl, "Foss. Flora d. Steink.-Form. Westph.," *Palaeontographica*, Band xviii, p. 59, pl. xxxi, figs. 1, 2.
1882. *Sphenopteris latifolia* Weiss, "Aus. der Flora der Steinkohlenformation" (*K. preuss. geol. Landesanst.*), p. 14, pl. xii, figs. 80, 80*a*. (Zweiter Abdr.)
1836. *Aspidites latifolius* Göppert, "Syst. foss. fil," *Nova Acta Acad. Leop.-Carol.*, xvii, p. 356. (*Excl. ref.* L. and H.)
1877. *Diplothmema latifolium* Stur, "Culm Flora," Heft 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 124 (230).
1885. *Diplothmema latifolium* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 361 (*non* pl. xxvi, figs. 1, 2).
1879. *Mariopteris latifolia* Zeiller, "Note sur le genre *Mariopteris*," *Bull. Soc. géol. France*, ser. 3, vol. vii, p. 98, pl. vi.
1883. *Mariopteris latifolia* Renault, "Cours de botan. foss.," vol. iii, p. 195, pl. xxi, figs. 16, 17.
1886. *Mariopteris latifolia* Zeiller, "Flore foss. du bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 161, pl. xvii, figs. 1, 2; pl. xviii, fig. 1.
1899. *Mariopteris latifolia* Hofmann and Ryba, "Leitpflanzen d. paläoz. Steinkohl.," p. 45, pl. v, figs. 10, 10*a*.
1907. *Mariopteris latifolia* Zalessky, "Flore foss. terr. houil. du Donetz," *Bull. Comité géol. Russie*, vol. xxvi, p. 389, text-fig. 14.
1910. *Mariopteris latifolia* Renier, "Documents pour l'étude de la paléont. du terr. houil.," pl. lxxxvi.
1923. *Mariopteris latifolia* Gothan in Gürich, "Leitfossilien," Lief. 3, p. 40, pl. vii, fig. 2.
1912. *Mariopteris latifolia* Huth in Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8, No. 149, figs. 1–3.
1914. *Mariopteris latifolia* Arber, "Foss. Flora Kent Coalfield," *Quart. Journ. Geol. Soc.*, vol. lxx, p. 71, pl. xiii, fig. 4.
1879. *Pseudopecopteris latifolia* Lesquereux, "Coal Flora," vol. i, p. 215 (? pl. lii, figs. 4, 4*a*).
1883. *Diplothmema belgicum* Stur, "Morphologie u. Syst. d. Culm-u. Carbonfarne," *Sitz. k. Akad. Wissensch.*, Band lxxxviii, Heft 1, p. 194, fig. 42*a*.
1885. *Diplothmema belgicum* Stur, "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 406, pl. xviii, figs. 1, 2, 7, 8.
1888. *Diplothmema belgicum* Toula, "Die Steinkohlen," p. 187, pl. i, fig. 11.

Description.—Petiole naked, 4 mm. to 6 mm. in breadth, smooth, dichotomizing at apex at almost a straight angle and dividing the frond into two sections. The naked striated petiole of each section again divides at a very open angle, and the resulting arms form the rachises of the four primary pinnæ which compose the frond.

Primary pinnæ in upper region tripinnate, at base quadripinnate; rachis slightly flexuous, canaliculate on upper surface. The two superior primary pinnæ are triangular in form and larger than the inferior pair, which have a more sub-triangular or broadly lanceolate shape. Secondary pinnæ alternate, sub-triangular or lanceolate, free or touching laterally, the lower-situated frequently inequilateral; those which arise from the base of the primary pinnæ on the side within the angles made by the dichotomies of the petiole are smaller than those that spring from the side of the rachis facing outwards; rachis straight or slightly flexuous.

Pinnules alternate, oblique to rachis, oblong, lanceolate, or sub-triangular, contracted at the base, free or touching laterally; those on upper secondary pinnæ more or less united to each other.

The lower-placed oblong pinnules bear about three pairs of alternate forward-directed blunt lobes and an obtuse terminal lobe, with generally a small lobe at its base on each side; the sub-triangular pinnules are shorter and have fewer obtuse lobes. The basal anterior and posterior pinnules on each pinna have usually a prominent lateral lobe on their distal margin.

On the upper secondary pinnæ the pinnules are more or less united to each other, slightly oblique to rachis, entire, with obtuse apices. The margins of the pinnules or their segments, have sometimes a fine serration formed of small sharp, saw-like teeth.

The very slightly flexuous median vein extends to near the apex, where it divides once or twice. The lateral veinlets depart at an angle of about 45° from the median vein to the lobes, where they in turn give off alternate veinlets that divide once in their course to the margin of the pinnule. Sometimes an additional veinlet seems to enter the pinnule direct from the rachis.

Remarks.—*Mariopteris latifolia* is rare in Britain, and the few specimens I have seen were all very fragmentary. A small fragment is given at fig. 7, Pl. CXLIV, which shows, at the part marked x, one or two free pinnules that bear a few obtuse lobes. What is apparently the terminal portion of a primary pinna has been figured by the late Dr Arber.* On this example the pinnules are all more or less united to each other, and have obtuse or obtusely-pointed apices.

As these two small specimens give a most imperfect idea of the characters of the plant, I add here, at text-fig. 94, a figure of *Mariopteris latifolia*, copied from Zeiller.† This shows an almost complete frond, reduced in the figure to two-thirds its natural size. Only a small fragment of the smooth petiole is preserved. At its apex it divides into two arms which separate at a very open angle. Each of these arms again dichotomizes and produces the slightly flexuous rachises of the four primary pinnæ which compose the frond. The sub-triangular or broadly lanceolate secondary pinnæ within the fork at the base of the primary rachises are frequently shorter than those on the outer side of the rachis. These secondary pinnæ bear the tertiary pinnæ or pinnules, as one is inclined to regard them. Morphologically I believe they are tertiary pinnæ with more or less united pinnules, and the structure that has been described in the diagnosis given above (as pinnules attaining a length of 2 cm., with two or three pairs of lateral lobes into which enters a vein that gives off alternate, dichotomously-divided lateral veinlets) has an arrangement of veinlets which is much more suggestive of a pinnule than of a lateral lobe, but lobes, pinnules, and pinnæ pass imperceptibly into one another.

The example shown at text-fig. 94 illustrates very clearly the dense and solid type of growth of the frond of *Mariopteris latifolia*. It is true that the four specimens figured by Brongniart, which show only fragments of primary pinnæ, do not perhaps represent so dense a type of growth, but that character is quite observable on his figures. To show more clearly the form of the pinnules, a small portion of

* *Loc. cit.*

† *Bull. Soc. géol. France*, ser. 3, vol. vii, pl. vi.

the same specimen as that shown at text-fig. 94 is given natural size at text-fig. 95. The basal anterior and posterior pinnules (which here might perhaps be more appropriately described as tertiary pinnæ) have a large lobe on the posterior margin,

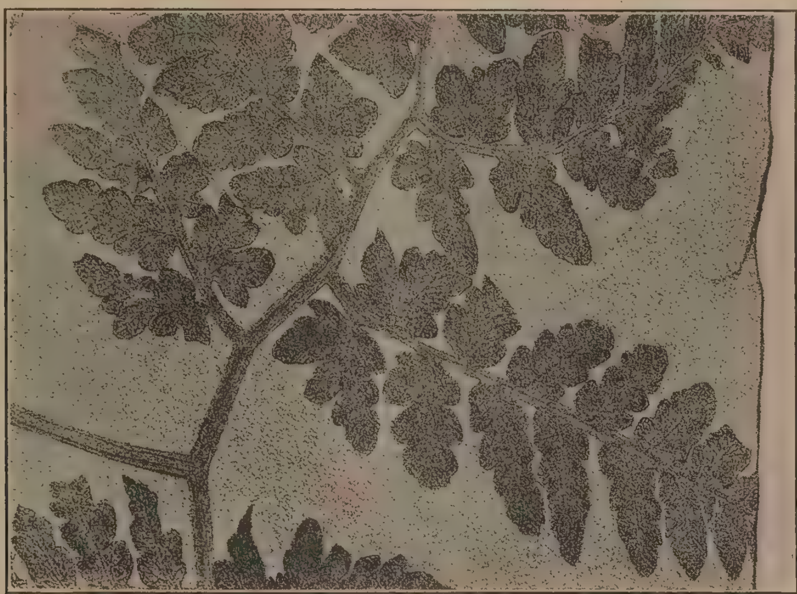
Text-fig. 94.—*Mariopteris latifolia* Brongniart sp. Almost complete frond showing the dichotomy of the petiole at its apex dividing the frond into two sections. Two-thirds natural size. After Zeiller.

which in turn becomes lobed and assumes the form of a pinnule; the upper lobes (or pinnules) are more or less united to each other, and if one had only such structures to consider, they, and those which succeed them on the rachis, could be well described as tertiary pinnæ. These lobes (or pinnules as one may regard them) have obtuse apices, with in some cases a tendency to have a more or less defined obtuse point.

This is seen in the enlargement of a pinnule given by BRONGNIART, and also on some of his figures. The margins of the pinnules and lobes are most frequently entire or smooth, but sometimes they bear small saw-like teeth; ZEILLER seems to have considered that normally they are present, but most usually obscured by being embedded in the rock.

From *Mariopteris acuta* Brongniart sp., *Mariopteris latifolia* differs in its obtuse pinnules and in its more dense type of growth, and from *Mariopteris Beneckei* Huth in the latter character and in its close pinnæ and pinnules. The lax type of growth of *Mariopteris Beneckei* gives that plant a very distinctive appearance.

STUR * figures and describes two specimens from Wigan (Lancashire) under the



TEXT-FIG. 95.—*Mariopteris latifolia* Brongniart sp. Portion of specimen given at text-fig. 94, but natural size, to show the form of the pinnules more distinctly. After ZEILLER.

name of *Diplothmema latifolium* Brongniart sp. These have a much more lax type of growth, with more distant secondary and tertiary pinnæ than are seen in *Mariopteris latifolia* Brongniart sp., and the segments of the pinnules have more sharply pointed apices. I scarcely think the plant is *Mariopteris latifolia* Brongniart sp., though I am unable to suggest the species to which it belongs.

A good deal of confusion in the accurate identification of *Mariopteris latifolia* Brongniart sp. in Britain has been caused through the plant so named by LINDLEY and HUTTON,† being what is now known as *Sphenopteris striata* Gothan, a species entirely distinct from *Sphenopteris latifolia* Brongniart.‡

* "Carbon-Flora d. Schatzlarer Schichten," p. 361, pl. xxvi, figs. 1, 2.

† "Fossil Flora," vol. ii, pl. clvi and vol. iii, pl. clxxviii.

‡ I take this opportunity of correcting an error in Part I of this Memoir. Since that was written I have received photographs of BRONGNIART'S type-specimen of *Sphenopteris obtusiloba* from my friend Prof. PAUL BERTRAND, of Lille, and I take this opportunity of expressing my thanks and indebtedness to him for his kind assistance. These photographs have convinced me that the plant which has been identified by palæobotanists for over eighty years as

Distribution.—*Mariopteris latifolia* Brongniart sp. is rare in Britain, but has a considerable vertical distribution, being recorded from the Staffordian, Westphalian, and Lanarkian Series. Notwithstanding this wide distribution, the species is represented by very few, and only fragmentary, specimens.

STAFFORDIAN SERIES.

Kent Coalfield.

? NEWCASTLE-UNDER-LYME GROUP.

Horizon: ?. *Locality:* Barfreston Boring, 6½ miles N.N.W. of Dover (E. A. N. Arber).

WESTPHALIAN SERIES.

North Derbyshire and Nottingham Coalfield.

Horizon: Above Top Hard Coal. *Locality:* Brindsley Clay Pit, Eastwood, Nottinghamshire (L. Moysey).

Northumberland and Durham Coalfield.

Horizon: ?. *Locality:* "Mines of Newcastle" (Brongniart).

LANARKIAN SERIES.

Fifeshire Coalfield.

Horizon: Coxtool Coal (= Six-foot Coal). *Locality:* East Newton, Wemyss (J. W. Kirkby).

Lanarkshire Coalfield.

Horizon: 16–17 feet above Pyotshaw Coal. *Locality:* Garrion Burn, ½ mile east of Overtown (Collection of Geological Survey, Edinburgh).

Mariopteris Soubeirani Zeiller.

Plate CXLVIII, figs. 1, 1*a*, 1*b*, 2, 2*a*.

1887. *Mariopteris Soubeirani* Zeiller, "Flore foss. du bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 167, pl. xix, fig. 1.

1912. *Mariopteris Soubeirani* Huth, "Foss. Gattung *Mariopteris*," Inaugural-Dissertation (Berlin), p. 61, fig. 21.

Brongniart's *Sphenopteris obtusiloba* is specifically distinct from that species, as pointed out by Gothan ("Oberschlesische Steinkohlenflora," Teil I, *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft 75, p. 24, pl. v, figs. 3, 3*a*; pl. vi, figs. 3, 3*a*, 1913), who has renamed the plant, so long misidentified, *Sphenopteris striata*.

The specimens described and figured by me in Part I (p. 27, Pl. III, figs. 1, 2, 3, 4, and Pl. IV, figs. 4 and 5) as *Sphenopteris obtusiloba* Brongniart are all referable to Gothan's *Sphenopteris striata*, as are also the records of the former species from localities mentioned for the distribution, on pp. 33 to 38. This will necessitate some alteration in the synonymy I have given; and I hope to deal more fully with this matter at a later date.

1912. *Mariopteris Soubeirani* Huth in POTONIÉ, " Abbild. u. Beschreib. foss. Pflanzen-Reste," No. 146, fig. 1.
1879. Cf. *Pseudopecopteris speciosa* Lesquereux, " Coal Flora," vol. i, p. 216, pl. li, figs. 1, 1*a*, 1*b*.
1893. Cf. *Mariopteris speciosa* White, " Flora of the Outlying Carb. Basins of South-western Missouri," *Bull. U.S. Geol. Survey*, No. 98, pp. 47, 49, 52.
1899. Cf. *Mariopteris speciosa* White in TAFF, " Geol. of the M'Alester Coal Fields," *U.S. Geol. Survey, Nineteenth Ann. Rept.* (1897–98), pt. 3, Economic Geol., p. 485.

Description.—Frond probably large. Primary pinnæ quadripinnate, rachis 3–5 mm. in breadth, smooth, or longitudinally striated and bearing somewhat distant, short, transversely-elongated ridges. Secondary pinnæ lanceolate or oval-lanceolate, alternate, attaining a length of 12 cm., touching each other laterally or slightly overlapping, rachis straight or slightly flexuous, canaliculate on upper surface and sometimes exhibiting small, transversely-elongated ridges. The secondary pinnæ borne within the fork of the section, especially towards its base, are shorter than those on the outer side of the rachis. Tertiary pinnæ alternate, lanceolate or narrow-deltoid, generally free but sometimes touching by their margins, pinnatifid on higher-placed pinnæ, pinnate on those holding lower positions and bearing five to six pairs of pinnules; rachis straight, canaliculate.

Pinnules alternate, decurrent, oval, oblong or deltoid, generally obtuse, sometimes with a blunt point, those on basal portions of lower-situated pinnæ slightly contracted at base, free, or united to each other; the posterior basal pinnule is usually larger than the others and has a more or less prominent blunt lobe on its posterior margin. Sometimes a small pinna, with a few pairs of confluent pinnules, occupies the place of the posterior basal pinnule. On the upper pinnæ the pinnules are sub-deltoid, usually obtuse, little or not contracted at the base, and generally more or less united to each other, the posterior basal pinnule has sometimes a slight lobe on the posterior margin, the others are usually entire. Limb of pinnule formed of a dense coriaceous tissue.

Nervation immersed; median vein strong, decurrent, dividing into a few veinlets shortly before reaching the apex, lateral veinlets given off at an acute angle, arcuate, and dividing once, or twice, in their course to the margin.

Remarks.—The only specimens of *Mariopteris Soubeirani* that I have seen are the two examples shown on Pl. CXLVIII, figs. 1 and 2.

Though beautifully preserved, that seen at fig. 1 is much broken. At the bottom of the figure part of the upper region of a primary pinna is seen, to which are attached a few broadly-lanceolate secondary pinnæ. The main rachis bears somewhat distant, short, transversely-elongated bars. These are not well seen on the figure, since the rachis holds a lower level on the stone than other portions of the specimen and is therefore not in sharp focus. Otherwise the rachis is smooth. The tertiary pinnæ on this fragment are lanceolate, free, and bear two or three pairs of alternate slightly oblique pinnules which are entire, have bluntly rounded apices, and are more or less united to each other.

On the upper corner of the same figure is a portion of a secondary pinna from a lower level. The alternate tertiary pinnæ on the posterior side are much longer than those on the anterior side of the rachis. The decurrent pinnules are free or only very slightly united to each other at the base and the posterior basal pinnule, especially on the lower-situated tertiary pinnæ, has a rounded lobe on the posterior margin. The other pinnules are entire, with blunt apices. The pinnæ end in an obtuse terminal lobe. Part of this fragment is enlarged two times at fig. 1*b*, which shows these features and the gutter-like furrow on the upper surface of the rachis.

A tertiary pinna, which has held a position nearer the base of a primary pinna than those just described, is given at fig. 1*a*, enlarged two times. Here, except at the apex, the pinnules are contracted at the base and entirely free, and in the place usually occupied by the basal posterior pinnule there is a short pinna which bears two pairs of pinnules and ends in a large obtuse terminal lobe. The free pinnules have one or two obtuse lobes on their posterior margin, while the uppermost pinnules are entire and become united to each other at the apex. The pinnules and lobes on this example have all more or less obtuse apices. The nervation is not very distinctly seen on this specimen as it is immersed in the coriaceous tissue of the pinnules. It consisted, however, of a strong decurrent median vein which divides into two dichotomous veinlets a short distance below the apex, and the decurrent pinnules, which are more or less united to each other, appear as if an additional veinlet or veinlets entered direct from the rachis (figs. 1*a*, 1*b*, and 2*a*). More probably these are derived from the median vein while still in the rachis, in the same manner as that seen to occur in the pinnules of *Mariopteris muricata*.*

Another specimen of *Mariopteris Soubeirani*, showing some fragments of secondary pinnæ, is given natural size on Pl. CXLVIII, fig. 2. The most perfect of these pinnæ is that which is still attached to a fragment of the primary rachis, about 4 mm. in breadth, which shows the distant, transversely-elongated bars. These bars are very narrow and about 1·5 mm. in length. Two slender thread-like ridges pass up the rachis.

The pinnæ are lanceolate, very slightly contracted at the base, and taper gradually to the apex. The apparent dichotomy at the apex of this pinna is caused by a fragment of the apex of another pinna accidentally lying across it. The tertiary pinnæ on this example are narrow-deltoid, those on the posterior side being longer than those on the anterior side of the rachis, and at the base they touch each other laterally, but are free on the upper part of the pinna. The pinnules are free on the basal pinnæ, but as these are traced upwards the pinnules become gradually more and more united to each other. The basal posterior pinnule has a large obtuse lobe on its posterior margin, and though some of the pinnules have obtuse apices, others are distinctly pointed. This is seen on the pinnæ enlarged two times at fig. 2*a*.

The nervation is not so distinctly seen on this specimen as on that given at fig. 1.

Mariopteris Soubeirani, as pointed out by Zeiller, is closely related to *Mariopteris speciosa* Lesquereux sp.,† but in the latter species the tertiary pinnæ are more

* See *ante*, p. 594. † *Pseudopecopteris speciosa* Lesquereux, "Coal Flora," vol. i, p. 216, pl. li, figs. 1, 1*a*, and 1*b*.

triangular, the pinnules seem to be habitually more or less united to each other, and the rachis is very distinctly flexuous or geniculate. The rachis is also said to be broadly winged in all its divisions, and as no reference is made to its having elongated transverse bars, it was presumably smooth.

I incline to the view that *Mariopteris Soubeirani* Zeiller is specifically distinct from *Mariopteris speciosa* Lesquereux sp., but it seems impossible to determine the relationship of the two species to each other without a comparison of authentic American examples with European specimens.

I am indebted to Mr W. Hemingway for both of my specimens of *Mariopteris Soubeirani*.

Distribution.—Very rare and known only from the under-mentioned locality.

WESTPHALIAN SERIES.

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Locality:* Monckton Main Colliery, near Barnsley (W. Hemingway).

Mariopteris Dernoncourti Zeiller.

Plate CLII, figs. 1, 2, 2*a*, 3, 3*a*; text-figs. 96, 97.

1886. *Mariopteris Dernoncourti* Zeiller, "Flore foss. du bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 169, pl. xix, fig. 2.

1912. *Mariopteris Dernoncourti* Huth, "Foss. Gattung *Mariopteris*," Inaugural-Dissertation (Berlin), p. 56, figs. 16–20.

1912. *Mariopteris Dernoncourti* Huth in Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8, No. 145, figs. 1–5.

1913. *Mariopteris Dernoncourti* Gothan, "Oberschlesische Steinkohlenflora," *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft lxxv, p. 97, pl. xxiii, fig. 1.

1915. ? *Mariopteris* cf. *Dernoncourti* Jongmans and Gothan, "Palaeobot.-strat. Studien," *Archiv für Lagerstättenforschung*, No. 18 (*K. preuss. geol. Landesanst.*), p. 176, pl. vi, fig. 3.

Description.—Petiole 9 mm. or more in breadth, with fine longitudinal striations and numerous short, narrow, transverse ridges, dichotomizing at the apex and dividing the frond into two sections.* The rachis of each section of the frond again dichotomizes, and the two arms spread out at right angles to their parent rachis and form the two primary pinnæ of the section. The primary pinnæ are at least quadripinnate, rachis 3 mm. or more in breadth, smooth, with short transverse bars and a few scattered blunt apiculi. Secondary pinnæ alternate, broadly lanceolate, margins overlapping, rachis straight, smooth, with a few scattered distant blunt-pointed apiculi, attaining a length of 12 cm. and often terminating at the summit in a naked more or less long spine-like prolongation of the rachis. Tertiary pinnæ alternate, usually free, sometimes touching laterally, lanceolate or broadly lanceolate,

* This description is founded on the evidence afforded by the petiole figured on Pl. CLII, fig. 3, at *a*, and described on p. 652.

rachis straight, canaliculate on upper surface, attaining a length of 3 cm. or more, and the larger bear at least six pairs of alternate pinnules.

Pinnules on lower-situated tertiary pinnæ free, oblique to rachis, ovate, obtuse, contracted at base and attached to rachis by a more or less broad footstalk; the basal posterior and anterior pinnules have usually a more or less pronounced lobe on the distal margin; on pinnæ holding a higher position the basal pair of pinnules are sub-quadrate with a shallow sinus on the upper margin or bilobate, oblique to rachis, contracted at base and attached by a broad footstalk, or similar to those on the lower-placed pinnæ; succeeding pinnules ovate, obtuse, with a slight basal lobe on posterior margin apical, pinnules entire or with slightly undulating margins: on uppermost tertiary pinnæ the basal pinnule on posterior side is sub-orbicular, entire; succeeding pinnules decurrent, ovate, obtuse or obtusely-pointed, and more or less united to each other, terminal lobe with an obtuse point.

Nervation usually distinct; median vein decurrent, extending to near the apex, where it divides into two arms; lateral veinlets depart at an acute angle, the lower usually divides twice in its arcuate course to the margin, though the lower arm sometimes remains undivided, the upper veinlets generally divide only once, while the uppermost may be undivided. All the veinlets are derived from the median vein, the basal one springing from its extreme base.

Remarks.—The specimen given at fig. 1, Pl. CLII, shows the top of one of the two arms of the petiole 4 mm. in breadth, dichotomizing into two branches. These form the rachises of two of the four primary pinnæ of the frond. The two rachises go off at almost right angles to the arm of the petiole, have a smooth surface with a few short transverse ridges and some scattered blunt-pointed apiculi, and bear the foliage pinnæ. The secondary pinnæ are lanceolate or broadly linear-lanceolate and touch each other laterally, have a slender rachis, and also bear a few distant blunt-pointed apiculi. The tertiary pinnæ are broadly lanceolate, oblique to rachis, decrease gradually from the base upwards, and end in a blunt or pointed terminal lobe.

The posterior basal pinnule on the lower pinnæ is free, broadly oval, and is larger than the other pinnules; sometimes a shallow sinus on the upper margin gives it a bilobed appearance, but more commonly it is broadly oval, with a very blunt apex. The anterior basal pinnule is also usually free, broadly oval and entire. The other pinnules are all more or less united to each other; usually their margins are entire, and frequently there is a blunt but distinct apex.

Some fragments of secondary pinnæ, rachises, and a petiole are seen natural size at fig. 3, Pl. CLII. At *a*, a petiole is broken over immediately below its apical bifurcation, and one can see the slight remains of the arms. It is 9 mm. in breadth and bears many close short transversely-elongated ridges and fine longitudinal striations, the latter being seen most distinctly where the thin coaly epidermis has fallen off. At *b* is seen part of the main rachis of a primary pinna. The petiole also bears transverse ridges mixed with a few blunt-pointed apiculi. In the centre of the figure is a fragment of a (?) primary pinna which gives off somewhat distant secondary pinnæ. The fragment of a secondary pinna seen at the lower end of the petiole, indicated by the letter *a*, bears distant tertiary pinnæ, four of which are enlarged two times at fig. 3*a*. The basal posterior pinnule has a very truncate form, and the corresponding pinnule on the opposite side of the rachis is only slightly more rounded at the apex. The succeeding pinnules are oblique, with obtuse apices, and are entire or have very slightly sinuous margins. The terminal lobe bears two lateral obtuse lobes, which, to judge by their nervation, represent two coalesced pinnules. The united bases of the pinnules form a narrow wing to the straight rachis. The surface of the pinnules is beautifully preserved and has a very fine papillose appearance, which appears to be caused by the epidermal cells. The entering vein runs almost parallel with the base, and from its outer margin gives off three lateral veinlets; the middle one dichotomizes twice, but that on each side usually only once, or may remain undivided.

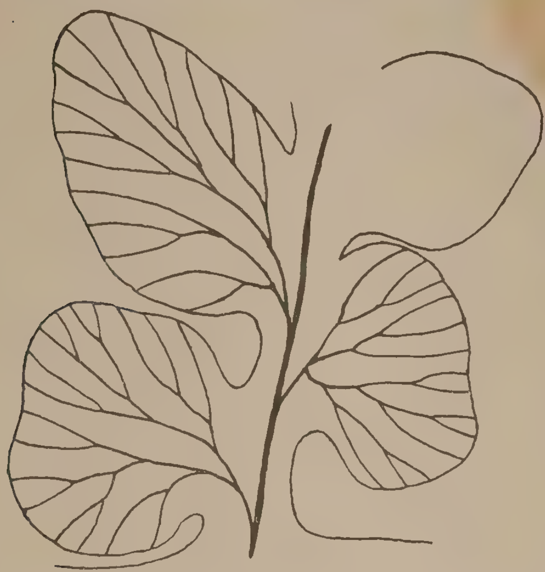
Another small specimen is given natural size at fig. 2. It shows a fragment of a secondary pinna which, as indicated by the size of the pinnæ and the pinnules being free on almost whole length of the pinnæ, is most probably derived from the lower portion of a larger and more divided primary pinna than the two examples described above. A small part of this specimen is enlarged two times at fig. 2*a* to show the form of the pinnules and their nervation. The lower basal pinnule on the posterior side is almost quadrate, with the base contracted into a broad footstalk. The vein divides into two branches immediately on entering the pinnule, and the two arms extend to the base of the little sinus on its upper margin. In their course to the margin they each give off three lateral veinlets. The middle one divides into four branches, those on either side divide only once. The basal pinnule on the opposite side of the rachis has a similar nervation. Each half of these pinnules contains the nervation seen in those of fig. 3*a*, and may be regarded as formed of two lateral lobes (text-fig. 96).

TEXT-FIG. 96.—*Mariopteris Dernoncourti* Zeiller. Pinnules from specimen shown at fig. 3*a*, Pl. CLII, enlarged seven times to show the nervation.

On the pinna at the base of fig. 2, the basal anterior and posterior pinnules have two lateral lobes, one on each side, and a blunt terminal lobe, and these lobes have a nervation very similar to that seen in the two halves of the basal pinnules given at text-fig. 97.

The pinnules which succeed these basal pinnules also have lateral flattened lobes, which are more prominently developed on the posterior margin than on the opposite side, where they are distinguished more by their nervation than by their prominence. As in other species of *Mariopteris*, the posterior basal pinnule is sometimes replaced by a short pinna which bears a few pairs of obtuse pinnules, as seen at *a* on fig. 2, Pl. CLII.

The three specimens described above, though varying in the size of the pinnules and the presence or absence of lateral lobes, and in their prominence, agree completely in their nervation and represent only portions of pinnæ of varying size and position on the frond. The enlargement given at fig. 2*a* agrees most perfectly with the enlargement given by Zeiller.*



Text-fig. 97.—*Mariopteris Dernoncourti* Zeiller. Basal pinnules enlarged seven times to show the nervation. From specimen given at fig. 2*a*, Pl. CLII.

Mariopteris Dernoncourti is easily separated from *Mariopteris acuta* Brongniart sp. by its obtuse pinnule-segments, which even when contracted into a point are usually more or less obtuse.

It is also easily separated from *Mariopteris Soubeirani* Zeiller by its much less robust habit and its lanceolate tertiary pinnæ, which have not the sub-triangular form of those of *Mariopteris Soubeirani.*

I have to express my thanks to Mr S. Nettleton and Mr W. Hemingway for the examples of this species which form the subjects of our figures.

Distribution.—Mariopteris Dernoncourti Zeiller is a very rare British species. A single specimen has been found in the upper part of the Lanarkian Series and only a small number in the Westphalian Series.

WESTPHALIAN SERIES.

Northumberland and Durham Coalfield.

Horizon : Yard Coal. *Locality :* Shiremoor Colliery, Shiremoor, $3\frac{1}{4}$ miles north-west of Tynemouth, Northumberland (J. Taylor Collection, Hancock Museum, Newcastle-on-Tyne).

Yorkshire Coalfield.

Horizon : Either Flockton or Joan Coal. *Locality :* Pildacre Colliery, Ossett (S. Nettleton).

Horizon : Parkgate Coal. *Locality :* Old Silkstone Colliery, Silkstone, 4 miles west of Barnsley (W. Hemingway).

Horizon : Barnsley Coal. *Locality :* Monckton Main Colliery, near Barnsley (W. Hemingway).

LANARKIAN SERIES.

Lanarkshire Coalfield.

Horizon : 16–17 feet above Pyotshaw Coal. *Locality :* Garrion Burn, $\frac{1}{2}$ mile east of Overtown (Collection of Geological Survey, Edinburgh, No. T1179d).

* *Loc. cit.*, pl. xix, fig. 2*a*.

Mariopteris Jacquoti Zeiller sp.

Plate CL, fig. 1 ; Plate CLI, figs. 2, 2*a*, 3 ; text-fig. 98.

1886. *Diplothmema Jacquoti* Zeiller, " Flore foss. du bassin houil. de Valenciennes," *Études Gîtes Min. France*, p. 157, pl. xviii, figs. 3–6.
1893. *Sphenopteris Jacquoti* Kidston, " The Carboniferous Flora of Yorkshire," *Trans. Yorks. Nat. Union*, pt. 18, p. 87.
1894. *Sphenopteris Jacquoti* Kidston, " Various Divisions of British Carboniferous Rocks," *Proc. Roy. Phys. Soc. Edin.*, vol. xii, p. 240.
1899. *Mariopteris* n. sp. (*Sphenopteris Jacquoti* (Zeiller ; Kidston)) White, " Foss. Flora Low. Coal Meas. Missouri," *Mon. U.S. Geol. Survey*, vol. xxxvii, p. 294 (*genus only*).
1912. *Mariopteris Jacquoti* Huth, " Foss. Gattung *Mariopteris*," Inaugural-Dissertation (Berlin), p. 82, fig. 41.
1912. *Mariopteris Jacquoti* Huth in Potonié, " Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8, No. 152, fig. 1.

Description.—Complete ramification of frond not known. Petiole or rachis naked and bearing many narrow transversely-elongated ridges, dividing at the apex into two arms which separate at a wide angle and form the rachises of two primary pinnæ. Primary pinnæ quadripinnate, rachis 5 mm. in breadth, straight, or very slightly flexuous, smooth, with numerous narrow transversely-elongated ridges. Secondary pinnæ alternate, broadly lanceolate or narrow-deltoid, free or touching laterally, rachis straight or very slightly flexuous, sometimes terminating in a naked spine-like extension of the rachis. Tertiary pinnæ alternate, more or less distinctly narrow-triangular, gradually contracting from the base to the apex and terminating in a blunt lobe ; free or touching laterally, rachis straight and standing almost upright to their parent rachis, attaining a length of 2 cm. or more. The larger bear four or more pairs of pinnules. The tertiary pinnæ also sometimes terminate in a spine-like prolongation of the rachis.

Pinnules alternate, formed of a thick leathery tissue, very variable in form and size, free or more or less united to each other, margins very convex and reflexed. When compressed the reflexed margins form a thickened border to the pinnules. On the larger and presumably lower-situated tertiary pinnæ the pinnules are free, ovate, contracted at the base, with an obtuse apex ; the basal anterior and posterior pinnules have a very large and prominent lateral lobe at the base of the distal margin, and the two basal pinnules are sometimes slightly shorter than the succeeding ones. The pinnules immediately above these are less contracted at the base and have a much smaller lobe on their posterior margin ; the upper pinnules are not contracted, distinctly decurrent, and become slightly united to each other. On the smaller tertiary pinnæ, which are more deltoid in form, the pinnules are free or are united more or less to each other. The basal posterior pinnule has an obtuse lobe on its posterior margin ; the upper pinnules are almost entire or with a slight sinuous margin, but seldom show distinctly developed lobes. Their apices are obtuse.

The uppermost secondary pinnæ are pinnate, the pinnules ovate, oblique to rachis, the lower slightly contracted at the base, entire, with obtuse points; the upper are more or less united to each other.

Nervation immersed, more distinct on the under than on the upper surface. Median vein decurrent, thick, extends to near the apex, where it divides into two arms; the lateral veinlets depart at a sub-acute angle and quickly arching outwards meet the margin of the pinnule at an open angle. They dichotomize at or close to their base, and in the lower part of the pinnule the upper arm of the fork again divides.

Remarks.—Though *Mariopteris Jacquoti* Zeiller sp. is somewhat imperfectly known, there seems little reason to doubt that it belongs to the form-genus *Mariopteris.* What are described here as tertiary pinnæ, four of which are enlarged two times at fig. 3, Pl. CLI, have much the appearance of the pinnules of some species of *Sphenopteris*; however, I think that the structures here under consideration are more correctly described as pinnæ-bearing pecopteroid pinnules, which may be lobed or entire, and the basal pinnules frequently show the characteristic *Mariopteris* lobe on their distal margin.

The specimen given natural size on Pl. CL, fig. 1, shows the bifurcation of the rachis or of an arm of the petiole, into two branches, each of which forms a rachis of a primary pinna. Though the base of the arm to the right is broken on its lower margin its connexion is maintained on the upper edge.

The two rachises separate at an angle of about 100°. The straight rachis of the primary pinna given off on the left is 5 mm. in breadth at the base, has a smooth surface, with numerous narrow transversely-elongated ridges from 0·5 mm. to slightly more than 1 mm. in length. The secondary pinnæ are alternate, lanceolate; the upper free, the lower touching or slightly overlapping. The alternate tertiary pinnæ are free, more or less deltoid, those on the posterior side being slightly larger than those on the other side of the rachis. The larger bear three or four pairs of pinnules. The pinnules are usually opposite on this specimen, but are sometimes sub-opposite. On the lower-situated and larger tertiary pinnæ the pinnules are free, the posterior basal pinnule is larger than the corresponding pinnule on the opposite side of the rachis and has a more prominent basal lobe on its distal margin. The succeeding pinnules have slightly undulated margins, and the terminal pinnule is obtuse and often has two slight lobes, one on each side of its base. A few tertiary pinnæ from this specimen are enlarged two times at fig. 3, Pl. CLI, to show the form of the pinnæ, the thickened border of the pinnules, and the transverse bars on the rachis of the primary pinna. Sometimes, though apparently rarely, a small pinna occupies the place of the posterior basal pinnule. This is seen at the letter *a* on fig. 1, Pl. CL.

At fig. 2, Pl. CLI, fragments of some pinnæ are given natural size. The pinnules are free at the base of the pinnæ, have blunt truncate apices, and the lowest pinnule has a notch on its upper margin. At fig. 2*a*, a fragment of a pinna is enlarged two times to show the form of the pinnules and their nervation. A single decurrent vein enters each pinnule; in the basal one, at its extreme base, it divides into two arms which keep close together and join the margin at the notch at its apex. These each give off lateral veinlets from their outer margin to supply the two halves of the pinnule. In their course to the margin the lateral veinlets usually divide once. The margins of the pinnules have a narrow thickened border.

TEXT-FIG. 98.—*Mariopteris Jacquoti* Zeiller sp. Fragments of pinnæ enlarged two times to show the nervation and form of pinnules. *Locality:* Monckton Main Colliery, near Barnsley, Yorkshire. *Horizon:* Barnsley Coal. Westphalian Series. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 1700.

Some fragments of pinnæ are enlarged two times at text-fig. 98, to show the variation in size and form of the pinnules and also their nervation.

At the upper margin of the text-figure, what is probably the apical portion of a primary pinna is seen. The secondary pinnæ are pinnate and the pinnules are more or less united to each other; they are oblique to the rachis, the upper entire, with blunt points, and the lower have feebly-developed marginal lobes. Some of them exhibit a slight indication of the thickened marginal border.

On the left margin and bottom of the figure are some pieces of pinnæ with much larger pinnules. The larger are about 7 mm. in length, slightly contracted at the base, oblique to the rachis, and have a prominent lobe at the base of their distal margin. On account of the removal of the carbonaceous substance of the pinnule the nervation is more distinctly seen than is usually the case. It consists of a decurrent median vein which dichotomizes a short distance below the apex of the pinnule and gives off sub-opposite lateral veinlets. These depart at a somewhat wide angle and dichotomize at a short distance from their base. The lower arm usually remains undivided, but the upper one divides. The uppermost lateral veinlet is only once divided. Doubtless, however, minor variations occur.

When specimens of *Mariopteris Jacquoti* are compressed and show the marginal border to the pinnules, it is easily distinguished from the other members of the genus, but even when this is absent the form of the tertiary pinnæ as seen on fig. 1, Pl. CL, the shape of the pinnules, and the nervation afford distinctive characters for the identification of this species.

Distribution.—Mariopteris Jacquoti Zeiller sp. is very rare in Britain and has been recorded only from the Westphalian Series.

WESTPHALIAN SERIES.

Forest of Wyre Coalfield.

Horizon: Brooch Coal. *Locality:* Kinlet Colliery, 1 mile south-west of Highley, Shropshire (T. H. Stonehouse).

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Localities:* South Kirkby Colliery, near Pontefract (W. Hemingway); Monckton Main Colliery, near Barnsley (W. Hemingway).

Mariopteris plumosa Kidston n. sp.

Plate CXLVII, figs. 1, 1*a*, 1*b*.

1886. *Sphenopteris cristata* Kidston (*non* Brongniart sp.), "Catal. Palæoz. Plants in British Museum," p. 74.

Description.—Complete ramification of frond unknown. Primary pinnæ deltoid, at least 15 cm. in length and about 13 cm. in width at broadest part, rachis straight and bearing transverse bars. Secondary pinnæ broadly linear-lanceolate, widest part a short distance above their base; basal secondary pinnæ within the angle formed by the dichotomy of the rachis, smaller than the corresponding pinnæ on the outer side of the rachis, the larger of which have a length of 8·5 cm. Tertiary pinnæ alternate, touching each other laterally, of almost equal width till near their apex, where they contract into a blunt point, rachis straight. They attain a length of 2 cm. and bear from three to seven pairs of pinnules. The tertiary pinnæ on the posterior side are longer than those on the anterior side of the rachis.

Pinnules alternate, oblique to rachis, oblong, decurrent, attached by the whole of their base, margins recurved, entire, sinuous, or with a few slight, blunt lobes. On the lower tertiary pinnæ the pinnules touch each other laterally, are free or only united to each other by their decurrent bases. On the middle and upper tertiary pinnæ the pinnules are more or less united to each other and the pinnæ almost assume the form of large, toothed pinnules, the basal anterior pinnule is generally larger and more free than the others, especially on the lower-situated tertiary pinnæ.

Nervation immersed. Median vein decurrent, thick, straight, extending to the apex and placed in a furrow. Lateral veinlets departing at an acute angle, placed in little furrows, and divide into two, three, or four branches in their course to the margin, according to the size and position of the pinnule they supply. The recurved margins of the pinnules and the arching up of the tissue of the limb between the veinlets give a wrinkled plumose appearance to the pinnæ.

Remarks.—The only specimen of this species known to me is that given natural size on Pl. CXLVII, fig. 1, of which portions are enlarged two times at figs. 1*a* and 1*b*.

Though the specimen is fragmentary it seems to show two of the four primary pinnæ of which the frond was composed. That the larger fragment is part of a pinna that arose through a dichotomy of the rachis is indicated by the pinnæ on the right side of the rachis being longer than those on its other side. This is a constant character of the secondary pinnæ of *Mariopteris*, which spring from the base of the rachis on the side within the fork. In the description of the species, the two pinnæ seen on our specimen are therefore treated as primary pinnæ.

On some of the tertiary pinnæ at the base of the primary pinnæ the pinnules are free, and thus show a quadripinnate division of the frond, while the upper-situated pinnæ, through the confluence of the pinnules, are only tripinnate-pinnatifid. A quadripinnate pinna is enlarged two times at fig. 1*b*, and two secondary pinnæ from a short distance above the base of the specimen are enlarged two times at fig. 1*a*. Here the pinnules on the tertiary pinnæ are seen to be united to each other throughout the greater part of their length, and the tertiary pinnæ are only pinnatifid.

The pinnules are decurrent and when free are oblong, of almost equal width till near the apex, where they terminate in an obtuse point. The basal pinnules have a few teeth, but their apices are almost invariably embedded in the matrix. They seem, however, to have ended in more or less sharp points. The margins of the upper pinnules are sinuous or entire, but on account of their being recurved it is possible that the lobes may have been more prominent than they appear on the specimen (fig. 1*b*).

The nervation is immersed in the tissue of the pinnule. The broad decurrent median vein lies at the bottom of a furrow and extends to the apex. The lateral veinlets, which are also placed in little furrows on the surface of the pinnule, depart at an acute angle and supply veinlets to each tooth or segment. The enlargements given at figs. 1*a* and 1*b* show the nature of the nervation, which, as a result of its being immersed, is frequently difficult to observe in detail.

Mariopteris plumosa differs from *Mariopteris Sarana* Huth * and *Mariopteris laciniata* Potonié † in the pinnules not being laciniate and in the plumose appearance of the frond.

My thanks are due to Sir Arthur Smith Woodward, F.R.S., for permission kindly given me to figure and describe the specimen, which is preserved in the Bowerbank Collection, Geological Department, British Museum, No. 52567.

* Huth in Potonié, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8, No. 150, figs. 1–4, 1912.

† *Ibid.*, No. 147, figs. 1, 2, note. This species is specifically distinct from *Pecopteris laciniata* Lindley and Hutton, "Fossil Flora," vol. ii, pl. cxxii, 1834.

Distribution.—The only known example of the species comes from the undermentioned locality.

RADSTOCKIAN SERIES.

SOMERSET AND BRISTOL COALFIELD.

RADSTOCK GROUP.

Horizon: ?. *Locality:* Camerton, 2 miles north of Radstock, Somerset.

Mariopteris obovata Kidston n. sp.

Plate CXLIX, figs. 6, 6*a*, 7, 7*a*.

Description.—Ramification of frond unknown. Ultimate pinnæ alternate, lanceolate, touching laterally, 4·5 cm. or more in length; rachis straight, slender. Pinnules alternate, oval or obovate, with rounded apices, oblique to rachis, decurrent and attached by their broad contracted base, entire except the basal anterior and posterior pinnules, which have a prominent obovate lobe on their distal margin. Terminal pinnule ovate or obovate.

Nervation distinct. Median vein decurrent, extending to near the apex, where it divides into four veinlets. Lateral veinlets depart at an acute angle, pursue a steep course, and meet the margin of the pinnule at an acute angle. In the side of the pinnule facing the apex of the pinna, the basal veinlet dichotomizes three times and ends in six veinlets at the margin of the pinnule; the next vein dichotomizes twice, and the uppermost pair only once.

Remarks.—The only examples of this species known to me are the two small specimens seen on Pl. CXLIX, figs. 6 and 7, which occur as impressions on a fine-grained, buff-coloured shale. They both show fragments of lanceolate ultimate pinnæ, which taper gradually to a point and end in an oblong or obovate terminal lobe. On the example given at fig. 7, the pinnules are decurrent, slightly smaller than those on the specimen seen at fig. 6, and are also more oval. They are attached by a wide base, and the basal pinnule on the posterior and anterior sides of the rachis have each a large lateral lobe on their distal margin. The lateral lobe is seen on the posterior pinnule of the pinna enlarged two times at fig. 7*a*. The nervation is similar to that of the other example,

The specimen given at fig. 6 of the same plate, though smaller, is more perfectly preserved. On this example the pinnules are obovate, decurrent, oblique to rachis, slightly less contracted at base, and have a broad attachment to the rachis. The terminal lobe is obovate. The basal posterior and anterior pinnules have each a large obovate lobe on their distal margin. This is distinctly seen on the uppermost pinna of fig. 6. A portion of this specimen is enlarged two times at fig. 6*a* to show the nervation. The decurrent median vein is thick and extends upwards for about three-quarters the length of the pinnule, when it divides into two arms; these again dichotomize a short distance before they reach the apex.

The lateral veinlets depart at a very acute angle, and almost without any curvature pursue an upward course to the margin of the pinnule.

Though the frond-build of this species is not known, the broad attachment of the pinnules to the rachis, their thick decurrent median vein, and the prominent lobes on the distal margin of the posterior and anterior pinnules are all characters which agree so completely with those of *Mariopteris* that the plant seems to find a natural place in this genus.

Mariopteris obovata has some resemblance to *Pecopteris elliptica* Bunbury,* but that species differs not only in the lateral veinlets departing at a much more open angle (and according to Bunbury, in their forking only once at their base, though Lesquereux † states that the lower ones fork again near the margin of the pinnule), but also in the absence of a lateral lobe on the posterior margin of the basal pinnules. This is better shown on Lesquereux's figure ‡ and that given by Fontaine and White § than on the type specimens.

Distribution.—Very rare and known only from the following locality.

WESTPHALIAN SERIES.

Forest of Wyre Coalfield.

Horizon : ?. *Locality :* Dowles Brook, near Bewdley, Worcestershire.

Mariopteris Loshi Brongniart sp.

Text-fig. 99.

1828. *Sphenopteris Loshii* Brongniart, " Prodrome," p. 51.
1836. *Pecopteris Loshii* Brongniart, " Hist. des végét. foss.," p. 355, pl. xcvi, fig. 6.
1841. Cf. *Sphenopteris latifolia* Göppert (*non* Brongniart) (*pars*), " Gatt. d. foss. Pflanzen," Lief. 3–4, p. 78, pl. xiv, fig. 5 (*non* fig. 6).
1845. *Pecopteris Loshii* Unger, " Synop. plant. foss.," p. 103.
1850. *Pecopteris Loshii* Unger, " Genera et species plant. foss.," p. 185.
1877. *Diplothmema Loshii* Stur, " Culm Flora," Heft. 2, *Abhandl. k. k. geol. Reichsanst.*, Band viii, p. 230 (124).
1869. *Pecopteris* (*Aspidides*) *Loshii* Schimper, " Traité de paléont. végét.," vol. i, p. 516.
1912. *Mariopteris Loshii* Huth, " Foss. Gatt. *Mariopteris* in geologischer u. botanischer Beziehung," Inaugural-Dissertation (Berlin), p. 83.
1912. *Mariopteris Loshii* Huth in Potonié, " Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8, No. 153, fig. 1.

Description.—Each of the two segments of the frond composed of two deltoid, bipinnate, primary pinnæ arising from a dichotomy of the petiole ; rachis slender, straight. Secondary pinnæ alternate, lanceolate, free or touching laterally, rachis

* *Pecopteris elliptica* Bunbury, " Fossil Ferns from Frostburg, Maryland," *Quart. Journ. Geol. Soc.*, vol. ii, p. 84, pl. vii, 1846.

† " Coal Flora," vol. i, p. 245. ‡ *Loc. cit.*, pl. xxxix, fig. 4.

§ " The Permian or Upper Carboniferous Flora of West Virginia and Pennsylvania," *Second Geol. Survey of Pennsylvania, Rept. of Progress*, p. 64, pl. xvii, fig. 1, 1880.

straight, those arising at the base of the rachis within the fork are much smaller than those situated on the outer side of the rachis. Pinnules alternate, ovate, with acute apex, free on greater portion of pinnæ, but becoming confluent at apex. On the secondary pinnæ, situated towards the base of the primary pinnæ, the basal posterior pinnule, and sometimes the anterior one, have a large lateral lobe on their distal margin, or the place of the posterior basal pinnule may be occupied by a small tertiary pinna. The median vein gives off slender, arcuate, lateral veinlets, which divide into two arms about half-way to the margin of the pinnule. As traced towards the apex, the secondary pinnæ assume the form of pinnules.

TEXT-FIG. 99.—*Mariopteris Loshi* Brongniart sp. New figure of BRONGNIART'S original specimen, copied from HUTH. Natural size.

Remarks.—The type of BRONGNIART'S *Pecopteris Loshi*, which came from the "Mines of Newcastle," is still preserved in the Museum of Natural History, Paris. HUTH * has given a new figure of the original specimen, which is reproduced here at text-fig. 99. BRONGNIART thought that the specimen probably showed an abnormal development of a frond, but it almost certainly represents one of the two principal sections of a *Mariopteris* frond. The basal pinnules are characteristic of the genus in having a large lateral lobe on their posterior margin.

The description given above is drawn up from a study of the figure given by HUTH, which is seen in our text-figure, and from BRONGNIART'S original description.

HUTH has suggested that *Mariopteris Loshi* is founded on a frond of a young

* HUTH in POTONIÉ, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8 (1912), No. 153.

and not fully developed plant, and does not represent a distinct species, but is most probably a young frond of *Mariopteris Dernoncourti* Zeiller; but the pinnules of *Mariopteris Loshi* appear to be more acute than those of *Mariopteris Dernoncourti*, and (as figured by BRONGNIART) the lateral veinlets are more numerous and spring in a much more regular manner from a prominent median vein than those of the last-named species. It is therefore better to treat *Mariopteris Loshi* as a species, at least provisionally, though I believe the specimen shows a portion of a frond of an immature plant, of which the mature condition may be known under another name.

Distribution.—LESQUEREUX recorded *Pecopteris Loshi* from Pottsville, Pennsylvania,* but in his "Coal Flora" he does not include the species, and his remarks † seem to cancel the record.

WESTPHALIAN SERIES.

NORTHUMBERLAND AND DURHAM COALFIELD.

Horizon: ?. *Locality*: "Mines of Newcastle" (Type of species, BRONGNIART, "Hist. des végét. foss.," pl. xcvi, fig. 6).

Mariopteris coarctata Stur sp. (? *non* Roehl sp.).

Plate CXL, figs. 2, 2*a*, 2*b*; Plate CXLIII, figs. 3, 3*a*.

1885. *Diplothmema coarctatum* Stur (*pars*), "Carbon-Flora d. Schatzlarer Schichten," *Abhandl. k. k. geol. Reichsanst.*, Band xi, Abth. 1, p. 370, pl. xxvi, figs. 6*a*, 6*b*.

1912. *Mariopteris muricata* Huth (*pars*) (? *non* Schlotheim, *non* Roehl) in POTONIÉ, "Abbild. u. Beschreib. foss. Pflanzen-Reste," Lief. 8, No. 143, fig. 1.

1912. *Mariopteris muricata* Huth (*pars*) (? *non* Schlotheim, *non* Roehl), "Foss. Gattung *Mariopteris*," Inaugural-Dissertation (Berlin), p. 41, fig. 8.

Remarks.—Under the name of *Sphenopteris coarctata*, ROEHL ‡ described a pinna of a *Mariopteris*. His specimen shows the termination of a penultimate pinna bearing alternate pinnæ. The penultimate pinna ends in a few spine-like points and the rachis of each of the ultimate pinnæ is also produced in the form of a spine. The alternate pinnules on the upper pinnæ are entire, while those on the pinnæ holding a lower level have three blunt lobes. On all the pinnæ the pinnules are more or less united to each other. On our specimens and on those mentioned above the pinnules are almost always free, even on the uppermost pinnæ.

That *Mariopteris* (*Sphenopteris*) *coarctata* Roehl is founded on the upper portion of a pinna of a *Mariopteris* is, I think, beyond doubt. HUTH has referred to *Mariopteris muricata*,§ a specimen very similar to our fig. 2, Pl. CXL. This "*coarctata*"

* ROGERS, "Geol. of Pennsylvania," vol. ii, pt. 2, p. 867.

† *Op. cit.*, vol. i, p. 206.

‡ *Sphenopteris coarctata* Roehl, "Foss. Flora Steink.-Form. Westphalens," *Palaeontographica*, Band xvii, p. 61, pl. xiv, fig. 5, 1869.

§ *Loc. cit.*

condition of growth occurs in *Mariopteris muricata*, *Mariopteris nervosa*, *Mariopteris hirta*, and *Mariopteris acuta*, where the rachis of the ultimate pinnæ is frequently produced as a spine-like point. Unfortunately all the specimens showing the typical "*coarctata*" condition have been fragmentary and cannot be definitely referred to any of the species that have a spine-like production of the rachis. The pinnules in the upper region of the pinnæ seem also to be somewhat modified in form, and it is more than probable that under the name of *Mariopteris coarctata* fragments of pinnæ of more than one species are included.

Two examples of the "*coarctata*" condition of a *Mariopteris* are figured here. That given on Pl. CXL, fig. 2, is very similar to the specimens figured by Stur and Huth,* but may not belong to the same species. The pinnules are mostly free and more or less of the sphenopteroid type, while on the type-specimen of *Sphenopteris coarctata* the pinnules show the species to belong to the pecopteroid group of the genus *Mariopteris*.

That given natural size on our Pl. CXL, fig. 2, has somewhat the character of *Mariopteris acuta*,† but does not quite agree, though the differences may be due to a greater or less reduction of the pinnules according to the extent in which the rachises are developed as naked spine-like projections. In the example given natural size on Pl. CXLIII, fig. 3, and enlarged two times at fig. 3*a*, there is an almost complete suppression of the pinnules.

As it is impossible to refer these specimens to their parent species, they are recorded here under the name of *Mariopteris coarctata* Stur (? *non* Roehl) sp., with whose specimen mentioned in the references they best agree.

Distribution.—"*Mariopteris coarctata*" is rare in Britain, but has been recorded from the undernoted localities.

WESTPHALIAN SERIES.

Yorkshire Coalfield.

Horizon: Barnsley Coal. *Localities:* East Gawber Colliery, near Barnsley (W. Hemingway); Monckton Main Colliery, near Barnsley (W. Hemingway); Woolley Colliery, Darton, near Barnsley (W. Hemingway).

South Wales Coalfield.

Horizon: ?. *Locality:* Centre of Settling's Bay, north of Little Haven, Pembrokeshire (Professor O. T. Jones).

LANARKIAN SERIES.

Clackmannanshire Coalfield.

Horizon: Roof of Splint Coal. *Locality:* Victoria Pit, ¼ mile east of Black Devon River, Tullygarth, 1 mile E.N.E. of Clackmannan (Collection of Geological Survey, Edinburgh).

* *Loc. cit.*

† See Pl. CL, fig. 2.

Mariopteris sp. (A).

Plate CXLVI, figs. 4 and 4*a*.

Description.—Penultimate pinnæ bipinnate, deltoid; rachis thick, straight, with two prominent lines, one near each margin. Ultimate pinnæ pinnate, alternate, lanceolate, oblique to parent rachis, free, attaining a length of 4 cm.; rachis straight, with a furrow on the upper surface.

Pinnules alternate, oblique to rachis, decurrent, the basal anterior and posterior pinnules obovate, contracted at the base, with a large lateral lobe on distal margin, attached by a broad footstalk; upper pinnules deltoid or triangular, with acute apex, and attached to the rachis by the full length of their base. Those on lower portion of pinna more distant than those on upper part, where they become united to each other; the lower and middle pinnules have a few irregularly-placed teeth or obtuse lobes, the upper pinnules have a slightly sinuous margin or are entire.

The nervation is immersed in the thick tissue of the pinnule and very imperfectly shown.

Remarks.—The only specimen of this plant that I have seen is given natural size on Pl. CXLVI, fig. 4. It shows a portion of a penultimate pinna, of which a part is enlarged two times at fig. 4*a*. The rachises of the primary pinnæ, as well as those of the secondary pinnæ, are thick and the former has two strong longitudinal ridges placed somewhat close to its margin. These are well seen on the enlargement given at fig. 4*a*. The basal anterior and posterior pinnules, especially on the lower ultimate pinnæ, have the characteristic *Mariopteris* lobe on their distal margin, and are slightly contracted at the base and attached to the rachis by a very broad footstalk. All the other pinnules are more or less triangular in form and united to the rachis by the whole of their base. Towards the apex of the pinnæ the pinnules become slightly united to each other, and the pinnæ end in a narrow, almost spine-like point. This is seen on the pinna which lies at the base of the specimen on the left side of fig. 4*a*.

The pinnules on the lower half of the pinnæ have a few irregularly-placed marginal teeth which usually end in somewhat sharp points, but the upper pinnules have only a slight sinuous margin or are entire.

The nervation is very imperfectly seen, being embedded in the tissue of the pinnules, which seems to have been of an almost coriaceous nature.

Distribution.—The only example of this plant that I have seen was derived from the Westphalian Series. It was collected by the Rev. R. H. Goode, to whom I am indebted for the specimen.

WESTPHALIAN SERIES.

Yorkshire Coalfield.

Horizon: Parkgate Coal. *Locality:* Mitchell's Main Colliery, Wombwell, 4½ miles south-east of Barnsley (Rev. R. H. Goode).

Mariopteris sp. (B).

Plate CXLVII, fig. 2.

Remarks.—An isolated pinna of a *Mariopteris* sp. is given natural size on Pl. CXLVII, fig. 2. It probably shows a secondary pinna bearing alternate tertiary pinnæ, on which the pinnules gradually become more and more united to each other as the tertiary pinnæ are followed from the base to the apex of the specimen.

The lowest tertiary pinna is contracted at the base, but the others, though slightly contracted, have a much broader attachment to the rachis. All the pinnules have convex margins and are more or less united to each other, those on the upper-situated pinnæ being more united than those on the pinnæ at the base. The posterior basal pinnule on the lowest pinna has a distinct lobe on its distal margin, but this lobe disappears on the corresponding pinnules of the upper pinnæ. The free portion of the pinnules is sub-triangular and ends in a point. The vein entering the pinnules divides two or three times to supply the lateral veinlets.

The single pinna that we have of this form probably held an upper position on a primary pinna, where the pinnules had become confluent and hence do not show their typical form. The specimen has a somewhat similar type of growth, however, to *Mariopteris plumosa*, and may be compared with the upper pinnæ of that species, as seen at fig. 1, Pl. CXLVII. The tertiary pinnæ on *Mariopteris* sp. (B), however, are very much broader in proportion to their length and have a more solid appearance. These differences appear to indicate a specific distinction.

In the meantime, for the purpose of reference, it is distinguished here as *Mariopteris* sp. (B).

Distribution.—The only example of *Mariopteris* sp. (B) that I have seen is that given on our plate.

WESTPHALIAN SERIES.

YORKSHIRE COALFIELD.

Horizon: Barnsley Coal. *Locality:* Elsecar Colliery, Wentworth.

Mariopteris sp. (C).

Plate CXLVIII, figs. 3, 3*a*.

Remarks.—A small specimen of a *Mariopteris* of the sphenopteroid group of the genus is given natural size on Pl. CXLVIII, fig. 3. It shows a portion of a penultimate pinna whose rachis is 3 mm. in breadth, very slightly flexuous, with fine longitudinal striæ, numerous small transversely-elongated ridges and prominent blunt-pointed apiculi, which are sometimes very slightly elongated and appear to be a modification of the transverse ridges more commonly seen on *Mariopteris* petioles. The ultimate pinnæ are alternate, somewhat oblique to the rachis, almost straight, and with fine longitudinal striations. The pinnules are alternate, of broadly oval or sub-rotund contour, and are divided into three to five obtuse or obtusely-pointed lobes. The basal pinnule on both the anterior and posterior side of the rachis has a larger lobe on its distal margin than on its posterior side. The dorsal surface of the pinnules is exposed, and the nervation, which has been immersed, is fairly well exhibited. It is seen at fig. 3*a* enlarged two times. In the trilobate pinnules the median vein extends only a short distance into the pinnule and gives off a branch to each lobe; it then dichotomizes three or four times and supplies the lobe with a radiating series of veinlets. The more oval pinnules are attached by a slightly broader base and have three or four lateral lobes; the median vein extends further into the pinnule and gives off lateral veinlets, which divide two or three times in their course to the margin of the pinnule.

In the form of its pinnules and their nervation this species has very much the character of the *Sphenopteris obtusiloba* * group of sphenopteroids, but differs in the larger size of all its parts; also the rachis is thicker and is marked with transversely-elongated ridges and blunt-pointed apiculi. It seems to form a distinct species, but our material is too fragmentary to justify the application of a specific name; accordingly, the specimen is here provisionally distinguished as *Mariopteris* sp. (C).

The only specimen I have seen is that shown on Pl. CXLVIII, fig. 3, and was collected by Mr D. Davies, to whom my thanks for the specimen are due.

STAFFORDIAN SERIES.

South Wales Coalfield.

BLACKBAND GROUP.

Horizon: Three Coals Seam (A). *Locality:* Glynogwr Colliery, Gilfach Goch, Glamorganshire (D. Davies).

Mariopteris sp. (D).

Plate CXLIX, figs. 1, 2, 3, 3*a*.

1907. *Mariopteris muricata* Zalessky (*non* Schlotheim) (*pars*), "Flore foss. terr. houil. du Donetz," I, *Bull. Comité géol. Russie*, vol. xxvi, p. 388, pl. xiv, figs. 6, 6*a*.

Remarks.—Three ultimate pinnæ of species of *Mariopteris* are given natural size on Pl. CXLIX, figs. 1–3. Fig. 1 probably represents a pinna from a lower position on the frond than that seen at fig. 2, while the pinna given at fig. 3 held a higher position than either.

In all the specimens the rachis is straight. On the example seen at fig. 3 the rachis has short transverse bars, and their absence on the other two specimens is most probably due to their state of preservation.

On the specimen seen at fig. 1 the pinnules at the base are free, oblong, and have

* *Sphenopteris obtusiloba* Brongniart, "Hist. des végét. foss.," p. 204, pl. liii, fig. 2.

an obtuse apex, but as followed towards the top of the pinna they gradually become less obtuse till at the apex they have sharp points and are united to each other. For about two-thirds the length of the pinna, from the base upwards, the pinnules on the posterior side have usually three small obtuse lobes on their distal margin, and the basal pinnule is bilobed, the lateral lobe on its distal margin being nearly as large as the other portion of the pinnule. On the anterior side of the rachis, the pinnules at the base have also three obtuse lobes, but on the pinnules above them the lobes are reduced to two, then to one, and finally the pinnules have entire margins. The median vein is straight in the lower pinnules and slightly decurrent in the upper ones. Close to the apex of the pinnule it divides into two arms. The lateral veinlets depart at an acute angle, are arcuate, and divide two or three times in their course to the margin.

A specimen which appears to be specifically identical with our plant has been figured by Zalessky * under the name of *Mariopteris muricata*, but it differs from that species in the form of the pinnules and the lateral lobes on their distal margin.

On the example given at fig. 2 the pinnules have a more or less triangular form, and at the base on the posterior side are short-triangular. All the pinnules have a more or less distinct auricle, or lobe, on their distal margin, but the lobe is most prominent on the posterior basal pinnule. The nervation is similar to that described above.

The pinnules on the third specimen given at fig. 3 are free at the base of the pinna, but become gradually more or less united to each other. They have entire margins, and the basal posterior pinnule has a large lobe on its distal margin, which, on account of the illumination of the specimen, is not clearly shown on fig. 3, but is well shown on fig. 3*a*, enlarged two times to show the form of the pinnules, their sub-acute apices, and the nervation. As in the other specimens, the lateral veinlets divide once or twice in their course to the margin.

The three figured specimens are all from the same locality and undoubtedly belong to one species, their differences being dependent on the relative position held by the pinnæ on the frond. Fig. 3 has a slight similarity to *Mariopteris nervosa* Brongniart sp., but it represents a much more robust species. Figs. 1 and 2, however, are essentially distinct from *Mariopteris nervosa* in the form of the pinnules and their lateral lobes. As I have been unable to discover any named species to which these specimens could be referred, I distinguish them provisionally as *Mariopteris* sp. (D), until the discovery of more complete specimens determines their systematic position.

I am indebted for the three figured specimens to Mr R. Weed, by whom they were collected. The only other example of this species that I have seen is a portion of a pinna, kindly given me by Mr W. H. Dyson.

Distribution.—Very rare; of the four known specimens three are from the Staffordian Series and the other from the Westphalian Series.

* *Loc. cit.*

STAFFORDIAN SERIES.

SOUTH WALES COALFIELD.

BLACKBAND GROUP.

Horizon: No. 2 Rhondda Seam. *Locality:* Standard Collieries, Ynyshir, Glamorganshire (R. WEED).

WESTPHALIAN SERIES.

YORKSHIRE COALFIELD.

Horizon: 129 yards above Barnsley Coal. *Locality:* Maltby Colliery Sinking, 7 miles S.S.W. of Doncaster (W. H. DYSON).

Mariopteris sp. (E).

Plate CLI, fig. 1.

Remarks.—The portion of a *Mariopteris* pinna given natural size on Pl. CLI, fig. 1, though small, is very well preserved and seems to differ from any described species known to me. The specimen is uncompressed, and the main rachis of the pinna is embedded in the matrix. The ultimate pinnæ are lanceolate, alternate, with a straight rachis, and terminate in a blunt-pointed pinnule which usually has one or two blunt lobes at its base.

The pinnules are alternate. On the lower pinnæ and at the base of the upper-situated pinnæ they are of a rhomboidal form with convex or reflexed margins and obtuse apices, contracted at base and attached by the median vein only. On the upper portion of the upper ultimate pinnæ the pinnules gradually become more united to the rachis, and finally assume the form of blunt-pointed sub-triangular pinnules connected with the rachis by the full length of their base. The basal posterior pinnule on the lower pinnæ has a lobe on its distal margin, but on the upper pinnæ the lobe is not so prominent, though the posterior half of the pinnule is slightly larger than the anterior half.

The nervation is immersed and consists of a thick, straight, median vein, placed in a little furrow, which extends to near the apex of the pinnule, where it branches into two arms. The lateral veinlets depart at an open angle and pursue a straight course to the margin. They divide once, but in the base of the larger pinnules one of the arms of the fork may again divide.

For the only specimen of this species that I have seen, I am indebted to Mr H. CULPIN, by whom it was collected.

WESTPHALIAN SERIES.

YORKSHIRE COALFIELD.

Horizon: 318 feet above Barnsley Coal. *Locality:* Bentley Shaft Sinking, 2½ miles north of Doncaster (H. CULPIN).

Mariopteris sp.

Plate CLIII, fig. 9.

Stem giving off roots.

A fragment of a *Mariopteris* stem, giving off roots, is seen natural size on Pl. CLIII, fig. 9. The stem is 1·5 cm. in breadth, and the cortex is smooth except for the numerous short transverse ridges on its outer surface. From one side a group of roots spring from a common point and on leaving the stem spread outwards. The largest root is about 2 mm. in width, but the great majority are only about 1 mm. in width. Mixed with these are fragments which may be parts of small roots, but no clear case of a lateral rootlet being given off from the roots has been observed.

Another small stem * from the same locality, only 6 mm. in width, bears small elevations on its surface, and also shows a small tuft of roots springing from its margin, the largest being about 0·60 mm. in width. The roots are more clearly seen individually than those on the specimen described above, but they likewise show no lateral rootlet being given off. In both cases, the roots are apparently borne on aerial stems. The specimens were collected by Mr W. Hemingway, from whom I received them.

WESTPHALIAN SERIES.

Yorkshire Coalfield.

Horizon : Barnsley Coal. *Locality :* Monckton Main Colliery, near Barnsley.

* Kidston Collection, No. 6594.

INDEX.

Note.—The names of genera and species described in this Memoir, with the essential page-references, are printed in Clarendon type.

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PLATE CXXIII.

Fig. 1. *Asterotheca Daubreei* Zeiller sp.
Portion of a primary pinna.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 3837.

Fig. 1*a*. *Asterotheca Daubreei* Zeiller sp.
Pinnules from last specimen from whose surface the villose covering has been removed, enlarged three times to show the nervation.

Fig. 2. *Asterotheca Daubreei* Zeiller sp.
Portion of a primary pinna.
Same locality and horizon as last.
Natural size. Kidston Collection, No. 3336.

Fig. 2*a*. *Asterotheca Daubreei* Zeiller sp.
Pinnules from last specimen, enlarged three times.

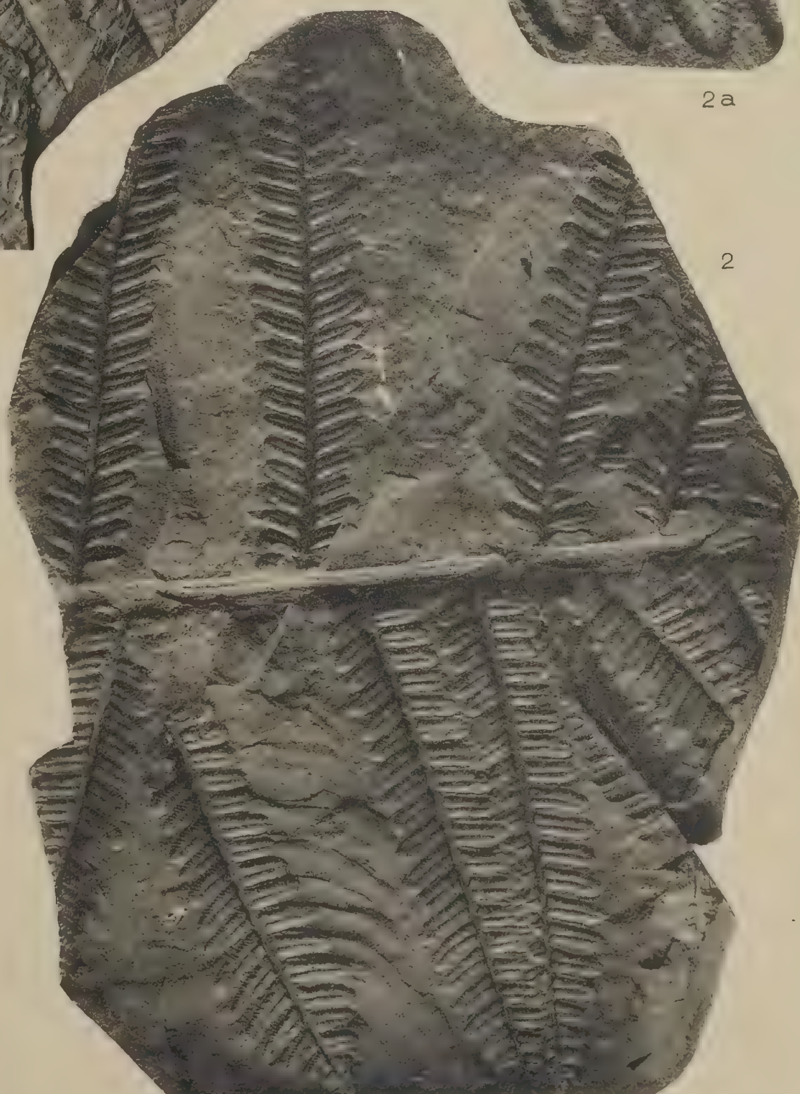
Fig. 3. *Asterotheca Daubreei* Zeiller sp.
Termination of a primary pinna.
Same locality and horizon.
Natural size. Kidston Collection, No. 572.

1a

1

2a

2



3

R Kidston.

Zinco Collotype Co. Edinburgh

PLATE CXXIV.

Fig. 1. *Asterotheca Daubreei* Zeiller sp.

Parts of two primary pinnæ.

Locality.—Wellsway Pit, Radstock, Somerset.

Horizon.—Radstock Group. Radstockian Series.

Natural size. Kidston Collection, No. 561.

Figs. 1*a*, 1*b*. *Asterotheca Daubreei* Zeiller sp.

Pinnules from same specimen, enlarged two times.

Fig. 1*c*. *Asterotheca Daubreei* Zeiller sp.

Pinnule from same specimen, enlarged about four times to show nervation and hirsute surface.

R. Kidston.

Zinco Collotype Co. Edinburgh

PLATE CXXV.

Fig. 1. *Asterotheca Daubreei* Zeiller sp.
Portion of a fertile primary pinna.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Collected by Mr G. West. Kidston Collection, No. 3852.

Fig. 1*a*. *Asterotheca Daubreei* Zeiller sp.
Portion of a sterile secondary pinna from same specimen, enlarged three times.

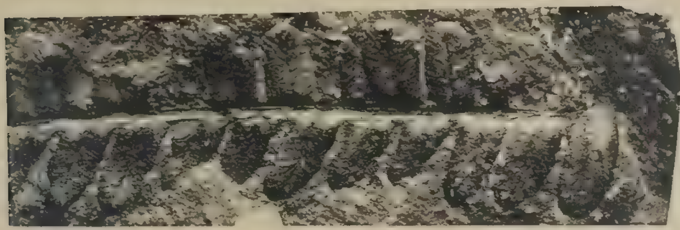
Fig. 1*b*. *Asterotheca Daubreei* Zeiller sp.
A fertile pinnule from same specimen, enlarged three times to show hirsute surface.

Fig. 1*c*. *Asterotheca Daubreei* Zeiller sp.
Pinnule from one of the upper sterile pinnæ of same specimen, enlarged seven times to show the nervation. (The hirsute surface is not indicated on the figure.)

Fig. 2. *Eupecopteris Fletti* Kidston n. sp.
Fragment of a primary pinna, showing crenulate margin of ultimate pinnæ.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 6075.

Fig. 2*a*. *Eupecopteris Fletti* Kidston n. sp.
Three ultimate pinnæ from same specimen, enlarged three times to show confluent pinnules and their nervation.

Plate CXXV.

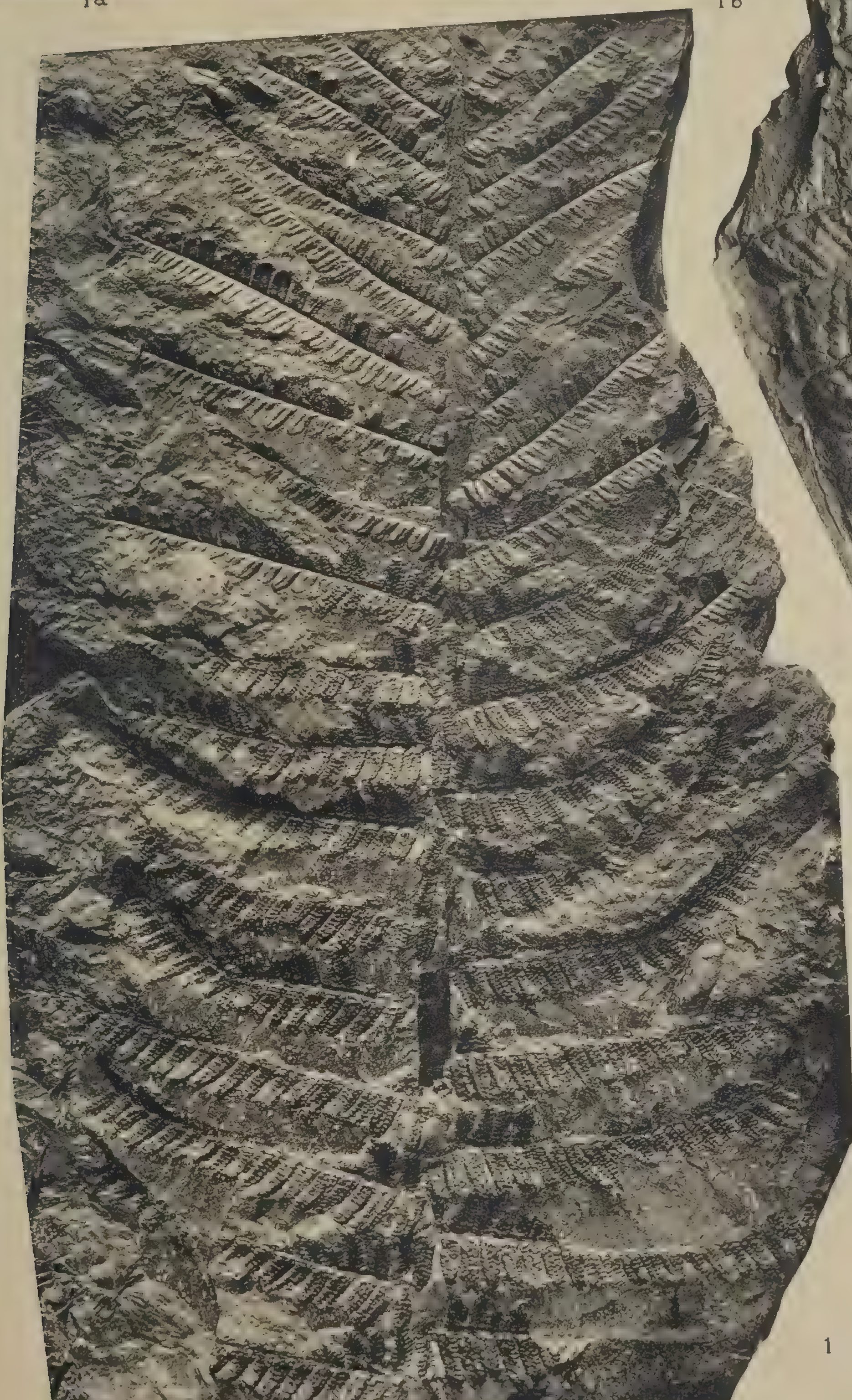


1a

1b

a

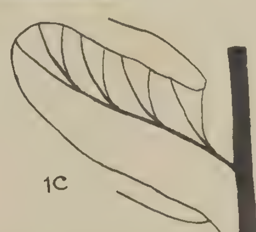
2



a

a

1



1c

2a

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PLATE CXXVI.

Fig. 1. *Asterotheca Lamuriana* Heer sp.

Portion of a primary pinna.

Locality.—Ludlow's Pit, Radstock, Somerset.

Horizon.—Radstock Group. Radstockian Series.

Natural size. Kidston Collection, No. 468.

Fig. 1*a*. *Asterotheca Lamuriana* Heer sp.

Portion of a secondary pinna from same specimen, enlarged two times to show the tertiary pinnæ, on which the pinnules are united to each other for half or more of their length and thus form a crenate margin to the pinna.

Fig. 1*b*. *Asterotheca Lamuriana* Heer sp.

Part of a tertiary pinna, enlarged six times to show the confluent pinnules and their nervation. From same specimen.

Fig. 2. *Asterotheca Lamuriana* Heer sp.

Fragments of secondary pinnæ, some of which are fertile.

Locality.—Braysdown Colliery, near Radstock, Somerset.

Horizon.—Radstock Group. Radstockian Series.

Natural size. Kidston Collection, No. 469.

Fig. 2*a*. *Asterotheca Lamuriana* Heer sp.

Portions of two secondary pinnæ, on which the upper portions of the lower tertiary pinnæ are fertile, while the upper tertiary pinnæ have assumed the form of entire sessile pinnules. Part of last specimen, enlarged two times.

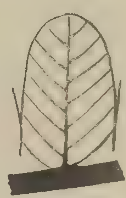
Fig. 2*b*. *Asterotheca Lamuriana* Heer sp.

Pinnule, enlarged about seven times to show the nervation.

1a

1

1b



2b

2

2a

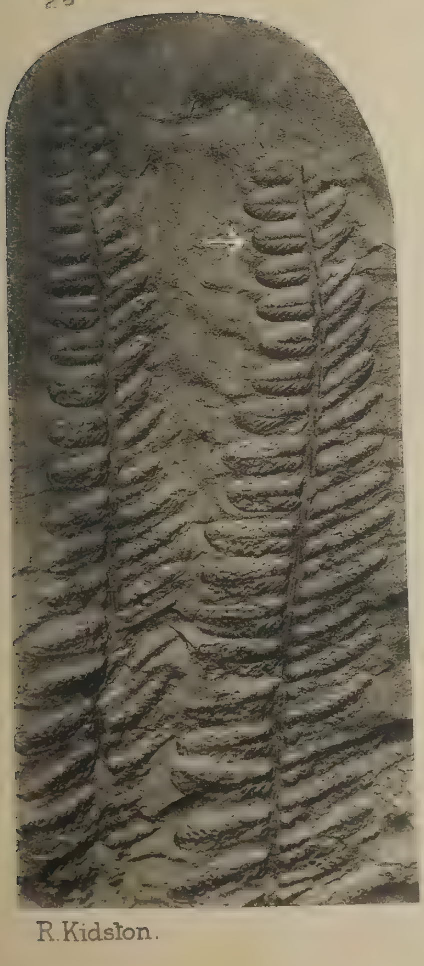


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PLATE CXXVII.

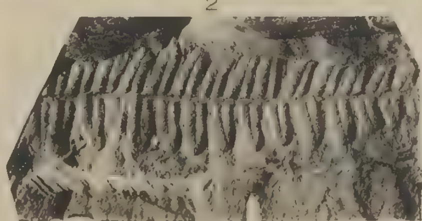
Fig. 1. *Asterotheca lepidorachis* Brongniart sp.
Portions of three primary pinnæ.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Collected by Mr G. West. Kidston Collection, No. 3845.

Figs. 1*a*, 1*b*. *Asterotheca lepidorachis* Brongniart sp.
Pinnules of last specimen, enlarged three times to show their nervation.

Fig. 2. Cf. *Asterotheca lepidorachis* Brongniart sp.
Part of a secondary pinna.
Locality.—Mynachdy Colliery, Old Ynysybwl, near Pontypridd, Glamorganshire.
Horizon.—Darrenddu Seam. Newcastle-under-Lyme Group. Staffordian Series.
Natural size. Collected by Mr D. Davies. Kidston Collection, No. 6072.

Fig. 2*a*. Cf. *Asterotheca lepidorachis* Brongniart sp.
Part of last specimen, enlarged two times to show the nervation.

1



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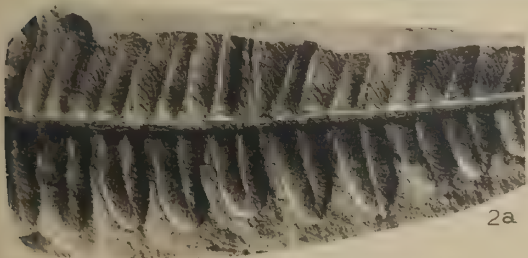
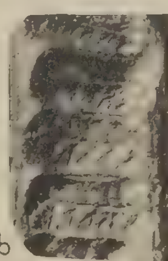


2a

1a



1b

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PLATE CXXVIII.

Fig. 1. *Acitheca polymorpha* Brongniart sp.

Portion of a primary pinna from the basal region of the frond, showing the quadripinnate condition of the primary pinnæ.

Locality.—Radstock, Somerset.

Horizon.—Radstock Group. Radstockian Series.

Natural size. Kidston Collection, No. 580.

Fig. 1*a*. *Acitheca polymorpha* Brongniart sp.

A tertiary pinna of last specimen, enlarged three times to show the form of the pinnules.

1

1a

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PLATE CXXIX.

Fig. 1. *Acitheca polymorpha* Brongniart sp.
Portion of primary pinna.
Locality.—Trafalgar Colliery, near Drybrook, Forest of Dean, Gloucestershire.
Horizon.—Newcastle-under-Lyme Group. Staffordian Series.
Natural size. Kidston Collection, No. 515.

Figs. 1*a*, 1*b*. *Acitheca polymorpha* Brongniart sp.
Pinnules of last specimen, enlarged three times to show the nervation.

Fig. 2. *Acitheca polymorpha* Brongniart sp.
Fragments of fertile primary pinnæ.
Locality.—Tying Pit, Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 513.

Fig. 2*a*. *Acitheca polymorpha* Brongniart sp.
Portion of last specimen, enlarged two times.

Fig. 3. *Acitheca polymorpha* Brongniart sp.
Spore-contents of a sporangium from last specimen. Enlarged twenty times.

Fig. 4. *Acitheca polymorpha* Brongniart sp.
Spores from same specimen, enlarged two hundred and fifty times.

Plate CXXIX.

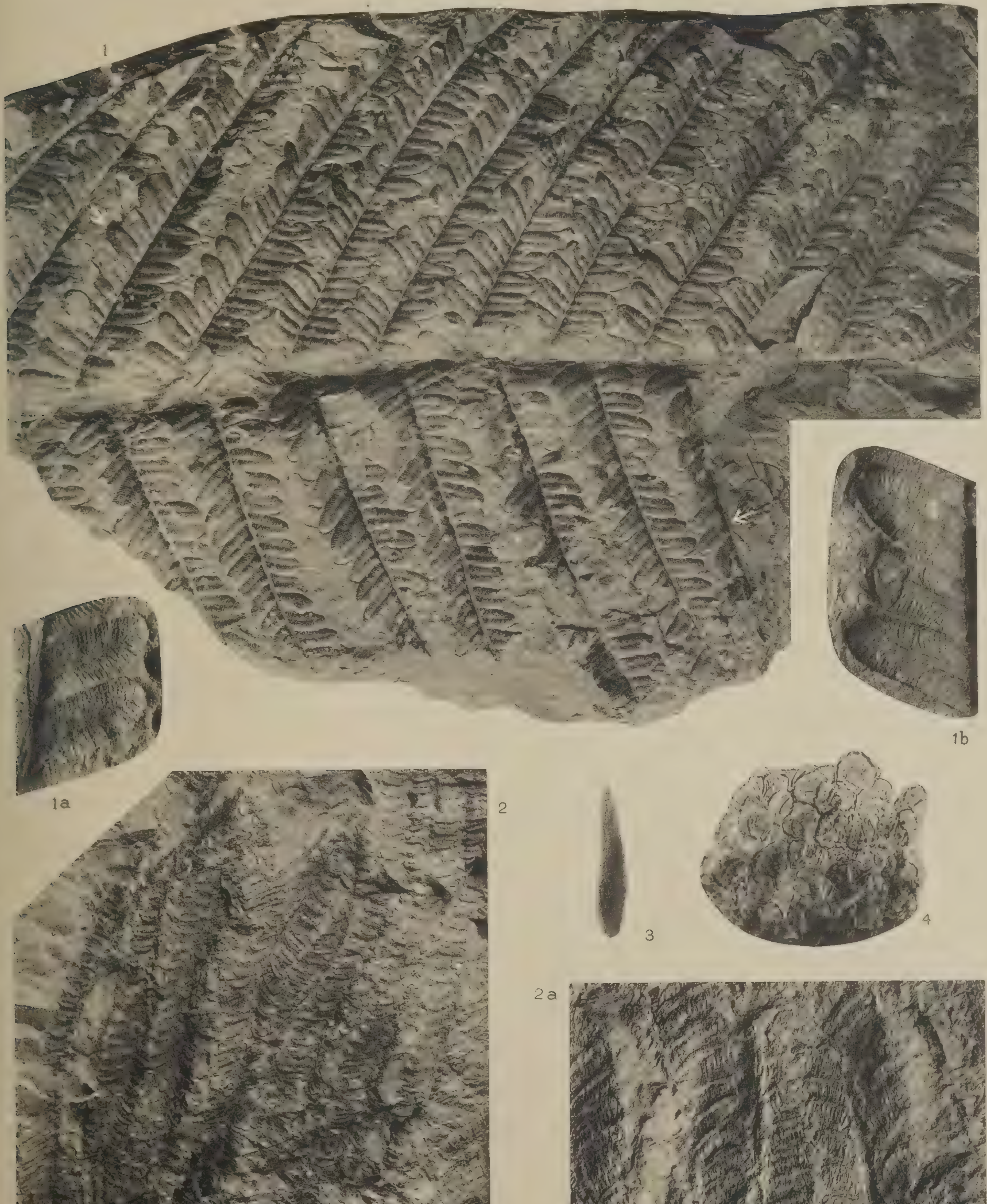

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PLATE CXXX.

Fig. 1. *Eupecopteris pteroides* Brongniart sp.
Part of a primary pinna.
Locality.—" Near Bath."
Horizon.—?. Radstockian Series.
Natural size. Collection of the British Museum, Geological Dept., No. 39050.

Fig. 1*a*. *Eupecopteris pteroides* Brongniart sp.
Pinnules from the same specimen, enlarged three times to show their nervation.

Fig. 2. *Callipteridium gigas* Gutbier sp.
Fragment of a secondary pinna.
Locality.—Bevan's Drift, about 1 mile north of Neath Station, Glamorganshire.
Horizon.—Wernffraith Seam. Farrington Group. Radstockian Series.
Natural size. Collection of Geological Survey, London, No. 47514.

Fig. 2*a*. *Callipteridium gigas* Gutbier sp.
Pinnules from last specimen, enlarged three times to show their nervation.

Fig. 3. *Acitheca polymorpha* Brongniart sp.
Two secondary pinnæ.
Locality.—Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 512.

Fig. 3*a*. *Acitheca polymorpha* Brongniart sp.
Pinnules from last specimen, enlarged three times to show their nervation.

Fig. 4. *Acitheca polymorpha* Brongniart sp.
Portion of a primary pinna.
Same locality and horizon as last.
Natural size. Collected by Mr R. Crookall. Kidston Collection, No. 6061.

Fig. 4*a*. *Acitheca polymorpha* Brongniart sp.
Part of a secondary pinna of last specimen, enlarged two times to show form of pinnules and their nervation.

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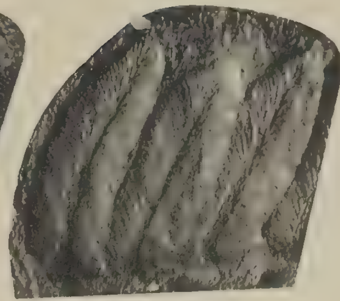
Palaeontology. Vol. II. 1925.

Plate CXXX.

2

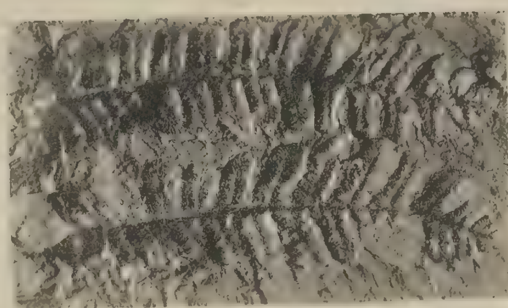
2a



1a

1

3.a



3

4a

4

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PLATE CXXXI.

Fig. 1. *Ptychocarpus unitus* Brongniart sp. forma *emarginatus* Göppert pro sp.
Fragment of a primary pinna with confluent pinnules.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 3853.

Fig. 2. *Ptychocarpus unitus* Brongniart sp.
Fragment of a primary pinna.
Locality.—Old Mills Pit, Farrington Gurney, Somerset.
Horizon.—Farrington Group. Radstockian Series.
Natural size. Kidston Collection, No. 493.

Fig. 2*a*. *Ptychocarpus unitus* Brongniart sp.
Pinnules from last specimen, enlarged two times to show the nervation.

Fig. 3. *Ptychocarpus unitus* Brongniart sp.
Terminal portion of a primary pinna.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Collected by Dr A. H. Foord. Kidston Collection, No. 465.

F g. 4. *Ptychocarpus unitus* Brongniart sp.
Fragment of secondary pinna.
Locality.—Braysdown Colliery, near Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 3854.

Fig. 5. *Ptychocarpus unitus* Brongniart sp.
Fragments of secondary pinnæ.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 491.

Fig. 5*a*. *Ptychocarpus unitus* Brongniart sp.
Pinnule of last specimen, enlarged two times to show nervation.

Fig. 6. *Ptychocarpus unitus* Brongniart sp. forma *emarginatus* Göppert pro sp.
Secondary pinnæ, in which the pinnules are united throughout their whole length.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 492.

Fig. 6*a*. *Ptychocarpus unitus* Brongniart sp. forma *emarginatus* Göppert pro sp.
Portion of pinna of last specimen, enlarged two times to show the nervation of the confluent pinnules.

Fig. 7. *Ptychocarpus unitus* Brongniart sp. forma *emarginatus* Göppert pro sp.
Fragment of a fertile secondary pinna with confluent pinnules, of which the lower bear synangia.
Locality.—Upper Conygre Pit, Timsbury, 2½ miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 496.

Fig. 8. *Ptychocarpus unitus* Brongniart sp.
Fragment of a secondary pinna with confluent pinnules.
Locality.—Old Mills Pit, Farrington Gurney, Somerset.
Horizon.—Farrington Group. Radstockian Series.
Natural size. Kidston Collection, No. 495.

Fig. 9. *Ptychocarpus unitus* Brongniart sp. forma *emarginatus* Göppert pro sp.
Fragment of a secondary pinna with confluent pinnules.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 497.

Fig. 9*a*. *Ptychocarpus unitus* Brongniart sp. forma *emarginatus* Göppert pro sp.
Two of the confluent pinnules enlarged two times to show the nervation.

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PLATE CXXXII.

Fig. 1. *Eupecopteris Bucklandi* Brongniart sp.
Portions of two primary pinnæ.
Locality.—Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 509.

Fig. 1*a*. *Eupecopteris Bucklandi* Brongniart sp.
Pinnules from same specimen, enlarged three times to show their form and nervation.

Fig. 1*b*. *Eupecopteris Bucklandi* Brongniart sp.
A pinnule from same specimen, enlarged about seven times to show the nervation.

Fig. 2. *Eupecopteris Bucklandi* Brongniart sp.
Portion of a secondary pinna, enlarged two times to show form of pinnule and nervation.
Locality.—Boring at Tower Brickworks, Folkestone, Kent.
Horizon.—At depth of 2950–2955 feet. ? Etruria Marl Group. Staffordian Series.
Collection of Geological Survey, London, No. 47515.

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PLATE CXXXIII.

Fig. 1. *Eupecopteris Fletti* Kidston n. sp.

Portions of two primary pinnæ.

Locality.—Wellsway Pit. Radstock, Somerset.

Horizon.—Radstock Group. Radstockian Series.

Natural size. Kidston Collection, No. 3839.

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PLATE CXXXIV

Fig. 1. *Eupecopteris Fletti* Kidston n. sp.

Portions of two primary pinnæ.

Locality.—Radstock, Somerset.

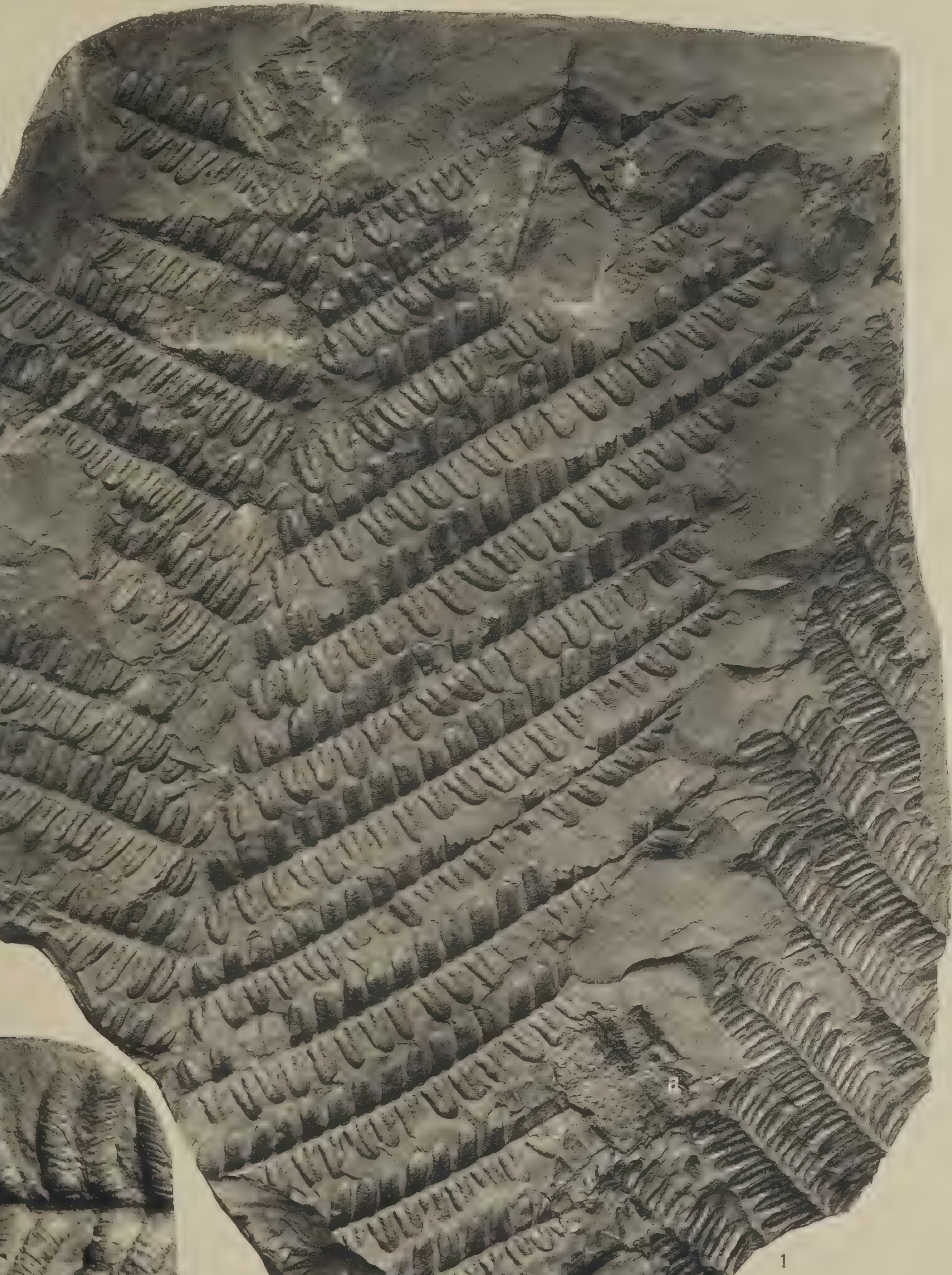
Horizon.—Radstock Group. Radstockian Series.

Natural size. Kidston Collection, No. 3847.

Figs. 1*a*, 1*b*. *Eupecopteris Fletti* Kidston n. sp.

Pinnules from same specimen, enlarged three times to show the nervation.

1a



1

1b

R Kidston

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PLATE CXXXV.

Fig. 1. *Eupecopteris Cisti* Brongniart sp.
Fragment of a primary pinna.
Locality.—Braysdown Colliery, near Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 3851.

Fig. 1*a*. *Eupecopteris Cisti* Brongniart sp.
Pinnules, enlarged three times to show nervation.

Fig. 2. *Pecopteris Armasi* Zeiller sp.
Fragment of a primary pinna.
Locality.—Wellsway Pit, Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1747.

Fig. 2*a*. *Pecopteris Armasi* Zeiller sp.
Part of a secondary pinna from same specimen, enlarged three times to show form of pinnules and their nervation.

Fig. 2*b*. *Pecopteris Armasi* Zeiller sp.
Pinnule from same specimen, enlarged six times to show nervation.

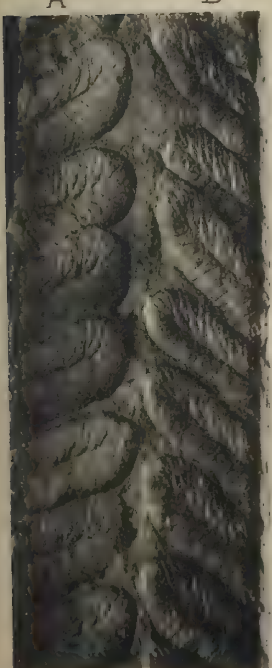
2a

2

2b

1

A B



1a

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PLATE CXXXVI.

Fig. 1. *Eupecopteris Volkmanni* Sauveur sp.
Fragment of a primary pinna.
Locality.—Shale Quarry, Old Roundwood Colliery, near Wakefield, Yorkshire.
Horizon.—Near outcrop of Stanley Main Coal. Westphalian Series.
Natural size. Collected by Mr STANLEY NETTLETON. Kidston Collection, No. 3703.

Fig. 2. *Eupecopteris Volkmanni* Sauveur sp.
Portions of two primary pinnæ.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 2392.

Fig. 2*a*. *Eupecopteris Volkmanni* Sauveur sp.
Part of a secondary pinna from last specimen, enlarged three times to show the form of the pinnules and their nervation.

Fig. 2*b*. *Eupecopteris Volkmanni* Sauveur sp.
Pinnule from same specimen, enlarged six times to show the nervation.

Fig. 3. *Eupecopteris Volkmanni* Sauveur sp.
Fragment of a quadripinnatifid condition of a primary pinna.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 1435.

Fig. 3*a*. *Eupecopteris Volkmanni* Sauveur sp.
Two tertiary pinnæ from last specimen, enlarged three times to show form of confluent pinnules and their nervation.

Figs. 3*b*, 3*c*. *Eupecopteris Volkmanni* Sauveur sp.
Portions of same specimen, enlarged six times to show form of confluent pinnules and their nervation.

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PLATE CXXXVII.

Fig. 1. *Asterotheca Daubreei* Zeiller sp.
Fragment of a primary pinna.
Locality.—Camerton, 2 miles north of Radstock, Somerset.
Horizon.—Radstock Group. Radstockian Series.
Natural size. Kidston Collection, No. 578.

Fig. 1*a*. *Asterotheca Daubreei* Zeiller sp.
Upper portion of three secondary pinnæ from last specimen, enlarged two times to show decurrent pinnules and their nervation.

Fig. 2. *Eupecopteris minor* Kidston n. sp.
Part of a primary pinna.
Locality.—Ardeer Pit, Stevenston, Ayrshire.
Horizon.—Seventeen feet below Five-quarter Coal. Lanarkian Series.
Natural size. Collection of Mr John Smith.

Fig. 2*a*. *Eupecopteris minor* Kidston n. sp.
Part of a secondary pinna from last specimen, enlarged two times to show the form of the tertiary pinnæ and the confluent pinnules.

Fig. 3. *Eupecopteris minor* Kidston n. sp.
Fragment of a primary ? pinna.
Same locality and horizon as last specimen.
Natural size. Collection of Mr John Smith.

Fig. 4. *Pecopteris integra* Andrae sp.
Upper portion of a primary ? pinna.
Locality.—Graiglas, Gilfach Goch, Glamorganshire.
Horizon.—No. 2 Llantwit Seam. Farrington Group. Radstockian Series.
Natural size. Collected by Mr D. Davies. Kidston Collection, No. 6073.

Fig. 4*a*. *Pecopteris integra* Andrae sp.
Same specimen as last, enlarged two times to show the form of the pinnules.

Plate CXXXVII.

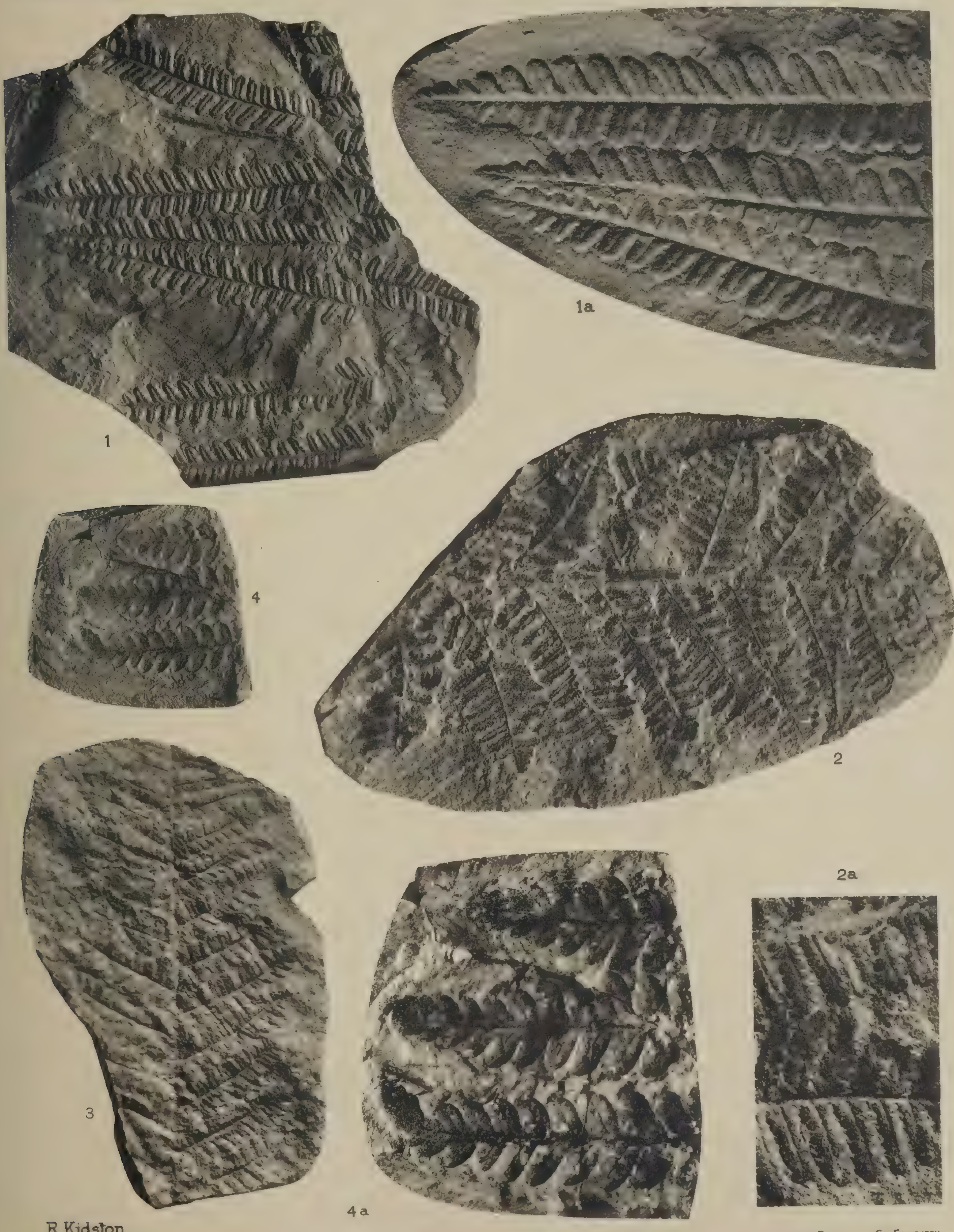

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PLATE CXXXVIII.

Fig. 1. *Mariopteris muricata* Schlotheim sp.
Fragment of a frond.
Locality.—Upper Cymmer Pit, Porth, Glamorganshire.
Horizon.—Abergorky Seam. Westphalian Series.
Natural size. Collected by Mr W. Thomas. Kidston Collection, No. 4604.

Fig. 1*a*. *Mariopteris muricata* Schlotheim sp.
Part of an ultimate pinna from last specimen, enlarged two times to show the form of the pinnules.

Fig. 2. *Mariopteris muricata* Schlotheim sp.
Portion of a bipinnate pinna.
Locality.—Bardsley Colliery, Ashton-under-Lyne, Lancashire.
Horizon.—?. Westphalian Series.
Natural size. Collected by the late George Wild. Kidston Collection, No. 805.

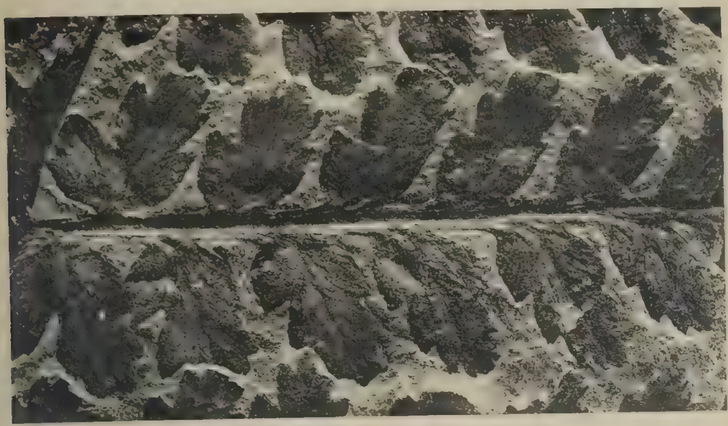
Fig. 3. *Mariopteris nervosa* Brongniart sp.
Fragment of a pinna.
Locality.—Kellybank, near Dollar, Clackmannan.
Horizon.—Blairgone Coal. Lanarkian Series.
Natural size. Kidston Collection, No. 4032.

Fig. 3*a*. *Mariopteris nervosa* Brongniart sp.
Some ultimate pinnæ from last specimen, enlarged two times.

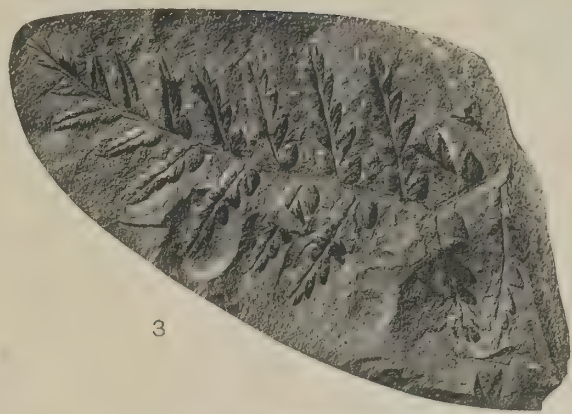
Fig. 4. *Mariopteris nervosa* Brongniart sp.
Portion of penultimate pinna.
Locality.—Blairpoint, Dysart, Fife.
Horizon.—Base of Coal-bearing strata. Lanarkian Series.
Natural size. Kidston Collection, No. 4029.

Fig. 4*a*. *Mariopteris nervosa* Brongniart sp.
Portion of last specimen, enlarged two times to show form of pinnules and nervation.

Plate CXXXVIII.



1a



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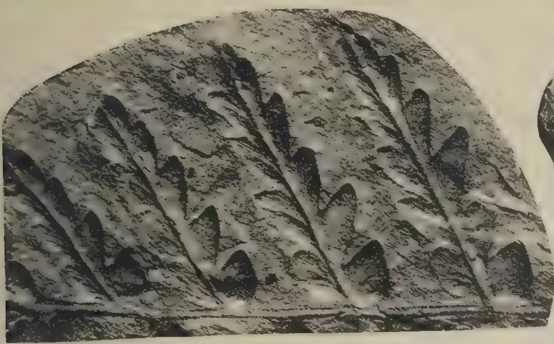
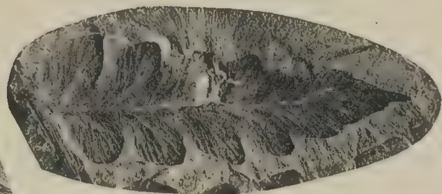
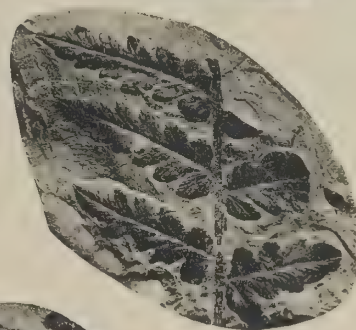


3a



4a



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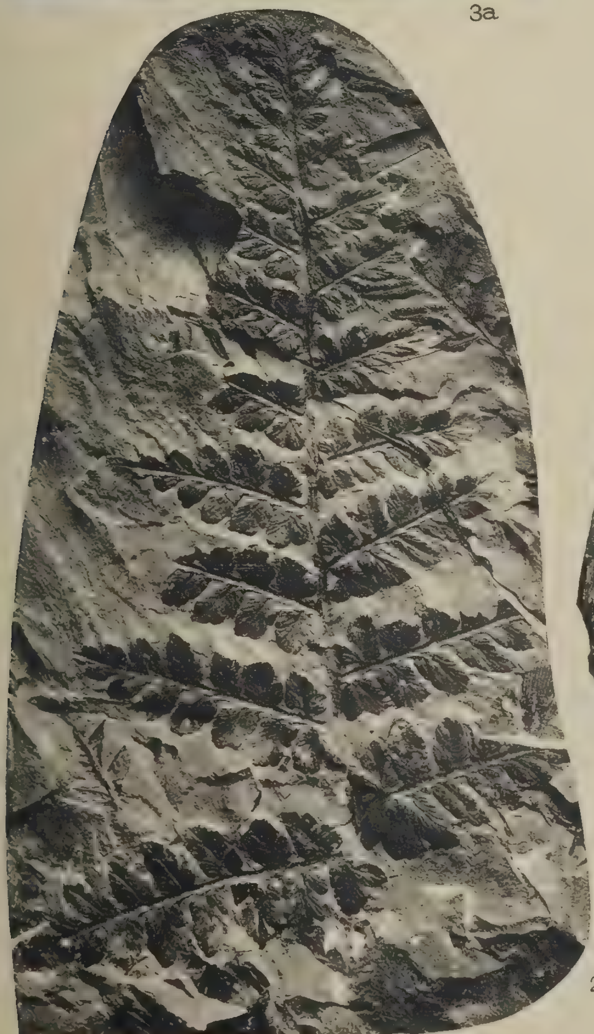

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1

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PLATE CXXXIX.

Fig. 1. *Mariopteris acuta* Brongniart sp.

Portion of a frond.

Locality.—Tollcross, Glasgow, Lanarkshire.

Horizon.—?. Lanarkian Series.

Natural size. Collected by Mr G. E. Paterson. Kidston Collection, No. 2306.

Fig. 1*a*. *Mariopteris acuta* Brongniart sp.

Ultimate pinnæ from same specimen, enlarged two times.

1a

1

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PLATE CXL.

Fig. 1. *Mariopteris nervosa* Brongniart sp. var. *oblongata* Brongniart.
Fragment of a bipinnate pinna.
Locality.—Blairpoint, Dysart, Fife.
Horizon.—Base of Coal-bearing strata. Lanarkian Series.
Natural size. Kidston Collection, No. 4199.

Fig. 1*a*. *Mariopteris nervosa* Brongniart sp. var. *oblongata* Brongniart.
Ultimate pinna from last specimen, enlarged two times to show form of pinnules and nervation.

Fig. 2. *Mariopteris coarctata* Stur sp. (? *non* Roehl sp.).
Upper portion of a bipinnate pinna on which the rachises of all the pinnæ terminate in a naked spine-like point.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 2394.

Figs. 2*a*, 2*b*. *Mariopteris coarctata* Stur sp. (? *non* Roehl sp.).
Two ultimate pinnæ from the last specimen, enlarged two times to show the form of the pinnules and the spine-like termination of the rachises.

Fig. 3. *Mariopteris lobatifolia* Kidston n. sp.
Portions of bipinnate pinnæ.
Locality.—Bardsley Colliery, Ashton-under-Lyne, Lancashire.
Horizon.—Roof of Peacock Coal. Westphalian Series.
Natural size. Collected by the late George Wild. Kidston Collection, No. 804.

Fig. 3*a*. *Mariopteris lobatifolia* Kidston n. sp.
Portion of two ultimate pinnæ from last specimen, enlarged two times to show the form of the pinnules.

Plate CXL.

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PLATE CXLI.

Fig. 1. *Mariopteris hirta* Stur sp.

Portion of a frond showing the division of the petiole at its apex into two arms, each of which again dichotomizes.

Locality.—Trane Colliery, Gilfach Goch, Glamorganshire.

Horizon.—Pentre Seam. Westphalian Series.

Natural size. Collected by Mr D. Davies. Kidston Collection, No. 6083.

Fig. 1*a*. *Mariopteris hirta* Stur sp.

Portion of petiole, enlarged two times to show the transverse ridges and small apiculi.

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PLATE CXLII.

Fig. 1. *Mariopteris Sauveuri* Brongniart sp.

Termination of one of the four primary pinnæ of the frond.

Locality.—Whitehaven Brickworks, Low Road, Whitehaven, Cumberland.

Horizon.—? Staffordian Series.

Natural size. Collection of the Geological Survey, London, No. 47516.

Fig. 2. *Mariopteris Sauveuri* Brongniart sp.

Portion of a bipinnate pinna.

Locality.—Micklethwaite's Brickyard, Stairfoot, near Barnsley, Yorkshire.

Horizon.—Shale over Oaks Rock. Westphalian Series.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 5056.

Fig. 3. *Mariopteris Sauveuri* Brongniart sp.

Part of an ultimate pinna, enlarged two times to show the nervation.

Same locality and horizon as last specimen.

Collected by Mr W. Hemingway. Kidston Collection, No. 3724.

Fig. 4. *Mariopteris Sauveuri* Brongniart sp.

Specimen showing one of the two segments and part of the other, into which the frond is divided.

Locality.—Near Wakefield, Yorkshire.

Horizon.—Seventy-five yards above Stanley Main Seam. Westphalian Series.

Natural size. From specimen lent by the late John Gerrard.

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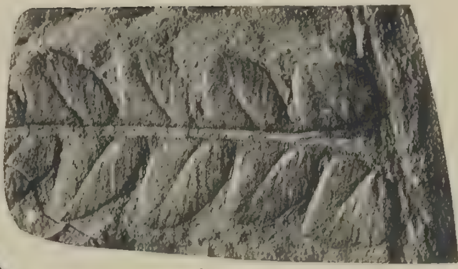

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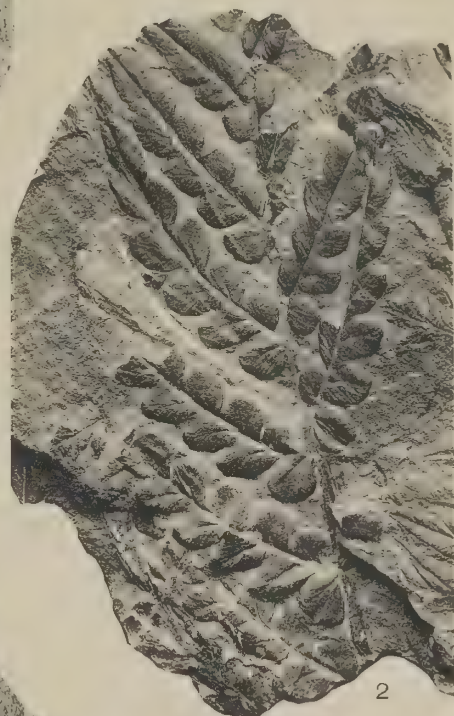

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PLATE CXLIII.

Fig. 1. *Mariopteris nervosa* Brongniart sp. forma *oblongata* Brongniart.
Fragment of a frond.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1947.

Figs. 1*a*, 1*b*. *Mariopteris nervosa* Brongniart sp. forma *oblongata* Brongniart.
Part of two pinnæ from last specimen, enlarged two times to show form of pinnules and nervation.

Fig. 2. *Mariopteris nervosa* Brongniart sp. forma *oblongata* Brongniart.
Fragments of pinnæ.
Same locality and horizon as last specimen.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1452.

Fig. 2*a*. *Mariopteris nervosa* Brongniart sp.
Part of a pinna from last specimen, enlarged two times to show nervation.

Fig. 3. *Mariopteris coarctata* Stur sp. (? *non* Roehl sp.).
Terminal portion of a pinna showing the suppression of the pinnules and the development of the rachises and median veins as spine-like prolongations.
Locality.—Woolley Colliery, Darton, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1228.

Fig. 3*a*. *Mariopteris coarctata* Stur sp. (? *non* Roehl sp.).
The same specimen, enlarged two times to show more distinctly the suppression of the pinnules and the naked and somewhat flattened rachises and median veins developed as spine-like extensions.

Fig. 4. *Mariopteris hirta* Stur sp.
Apex of an ultimate pinna, showing the spine-like prolongation of the rachis.
Locality.—Crigglestone Colliery, 4 miles south-west of Wakefield, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Enlarged two times. Collected by Mr W. Hemingway. Kidston Collection, No. 6104.

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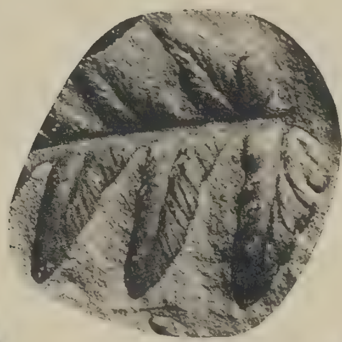

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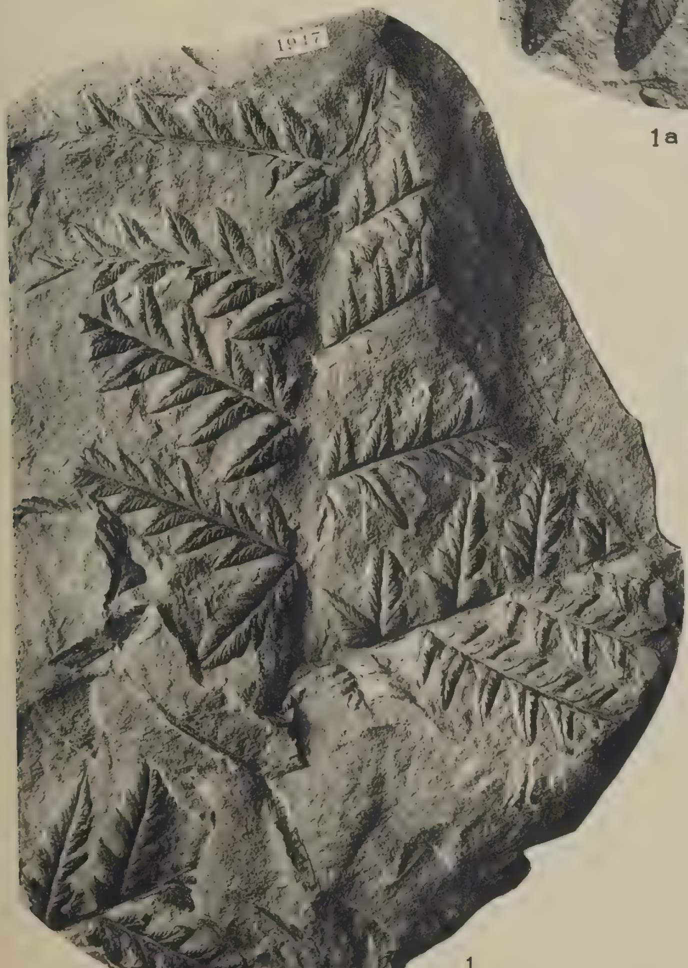

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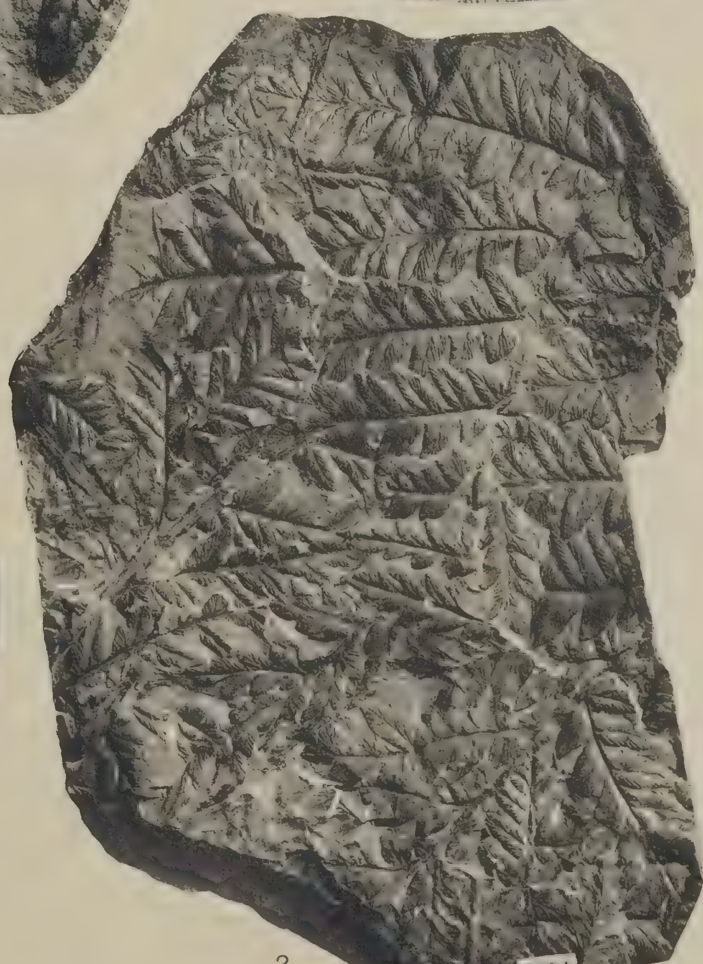

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PLATE CXLIV.

Fig. 1. *Mariopteris nervosa* Brongniart sp.
Rachis bearing a " bulbil "-like expansion at its apex.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 5001.

Fig. 2. *Mariopteris hirta* Stur sp.
Portions of pinnæ.
Locality.—East Gawber Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1446.

Fig. 2*a*. *Mariopteris hirta* Stur sp.
Ultimate pinna from last specimen, enlarged two times to show nervation and spine-like termination of pinna.

Fig. 3. *Mariopteris muricata* Schlotheim sp.
Fragment of bipinnate pinna.
Locality.—Crophead Pit, Sauchie, near Alloa, Clackmannanshire.
Horizon.—?. Lanarkian Series.
Natural size. Kidston Collection, No. 2576.

Fig. 4. *Mariopteris nervosa* Brongniart sp.
Frond of a very young plant.
Locality.—New Frickley Colliery Sinking (1904), Frickley, 3 miles north-east of Bolton-upon-Dearne, Yorkshire.
Horizon.—Ninety yards above Shafton Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 3729.

Fig. 4*a*. *Mariopteris nervosa* Brongniart sp.
The last specimen, enlarged two times to show more distinctly the form of the pinnules.

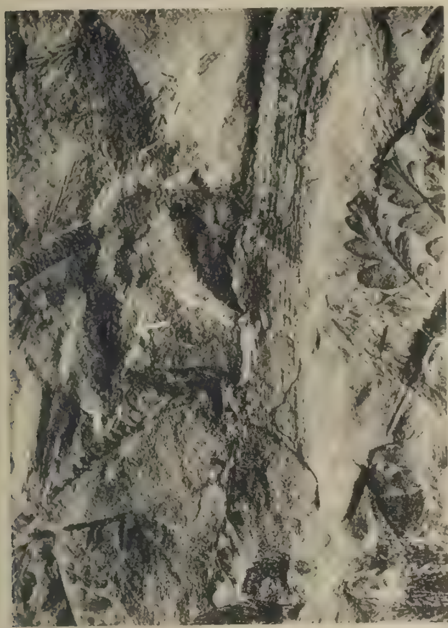
Fig. 5. *Mariopteris nervosa* Brongniart sp. forma *oblongata* Brongniart.
Form of the species, with long narrow pinnules on the lowest pinna.
Locality.—Patent Brick Co.'s Quarry, Dolly Lane, Leeds, Yorkshire.
Horizon.—Below Black Bed Coal. Westphalian Series.
Natural size. Collected by Mr J. W. Bond. Kidston Collection, No. 5875.

Fig. 6. *Mariopteris nervosa* Brongniart sp.
Portion of a bipinnate pinna.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1663.

Fig. 6*a*. *Mariopteris nervosa* Brongniart sp.
Ultimate pinna of last specimen, enlarged two times to show form of pinnules and nervation.

Fig. 7. *Mariopteris latifolia* Brongniart sp.
Fragment of an ultimate pinna.
Locality.—East Newton, Wemyss, Fifeshire.
Horizon.—Coxtool Coal (=Six-foot Coal). Lanarkian Series.
Natural size. Collected by Mr J. W. Kirkby. Kidston Collection, No. 967.

Plate CXLIV.



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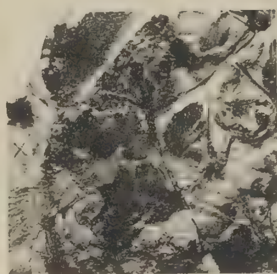

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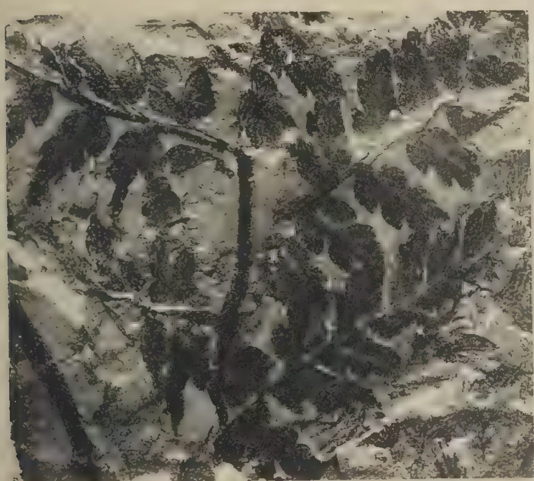

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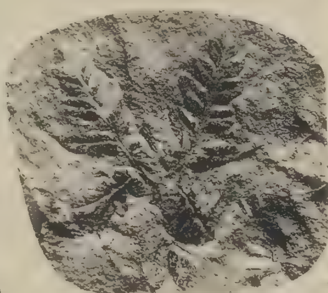

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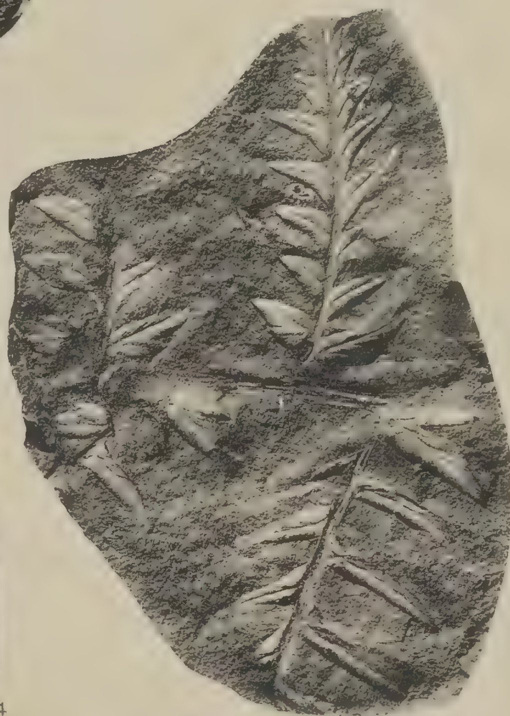

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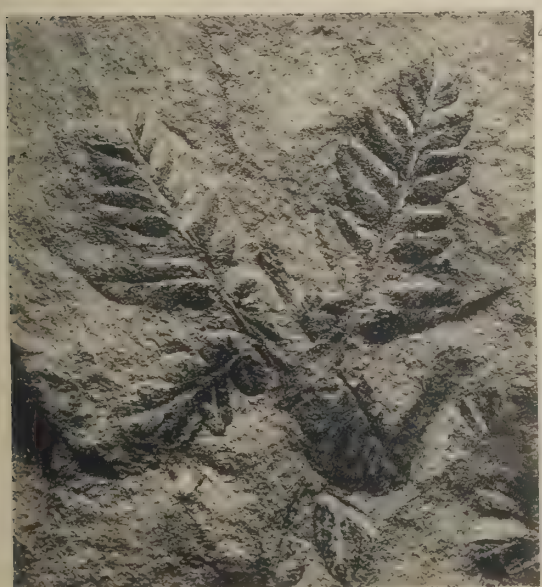

4a

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PLATE CXLV.

Fig. 1. *Mariopteris muricata* Schlotheim sp.

Pinnule from a low position on a pinna where the pinnules are free and contracted at base, showing the revolute margins and nervation. The apex of the pinnule is broken off. At *a* the base of a large glandular hair.

Locality.—Warsop Main Colliery, 5 miles north-east of Mansfield, Nottinghamshire.

Horizon.—Top Hard Coal. Westphalian Series.

Enlarged six and a half times. Collected by the Rev. R. H. Goode.

Fig. 2. *Mariopteris muricata* Schlotheim sp.

Pinnule from higher position on a pinna where the pinnules are attached by a broad base and slightly united to each other, showing the nervation and revolute margins. The pinnule terminates in a stellate glandular structure at *a*.

Enlarged eight times.

Fig. 3. *Mariopteris muricata* Schlotheim sp.

Pinnules from the apex of a pinna, showing their union to each other, the nervation and revolute margin.

Enlarged nine times.

Fig. 4. *Mariopteris muricata* Schlotheim sp.

Lower surface of pinnule, showing outline of the epidermal cells and portion of a veinlet.

Enlarged sixty times.

Fig. 5. *Mariopteris muricata* Schlotheim sp.

Upper surface of pinnule, showing outline of the epidermal cells and part of the median vein giving off a lateral veinlet.

Enlarged sixty times.

Fig. 6. *Mariopteris muricata* Schlotheim sp.

Sinus between two lobes, showing the revolute margin formed of square cells.

Enlarged fifty times.

Fig. 7. *Mariopteris muricata* Schlotheim sp.

Revolute margin, showing mixture of square and rhomboidal cells.

Enlarged one hundred and five times.

Fig. 8. *Mariopteris muricata* Schlotheim sp.

Bases of large capitate glandular hairs situated on the rachis.

Enlarged thirty times.

Figs. 9, 10. *Mariopteris muricata* Schlotheim sp.

Glandular hairs, showing columnar base and capitate head.

Enlarged one hundred and five times.

Fig. 11. *Mariopteris muricata* Schlotheim sp.

Upper portion of a pinnule, showing the apex to terminate in a stellate glandular structure.

Enlarged fourteen times.

(All the figures on this plate are from preparations made by Mr John Walton, of the University of Manchester, from a specimen collected by the Rev. R. H. Goode at the locality and horizon given at fig. 1.)

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PLATE CXLVI.

Fig. 1. *Mariopteris Daviesi* Kidston n. sp.
Fragment of a frond.
Locality.—Britannic Colliery, Gilfach Goch, Glamorganshire.
Horizon.—Five-foot Seam. Westphalian Series.
Natural size. Collected by Mr D. Davies. Kidston Collection, No. 5737.

Fig. 1*a*. *Mariopteris Daviesi* Kidston n. sp.
Three ultimate pinnæ of last specimen, enlarged two times to show more distinctly the form of the pinnules.

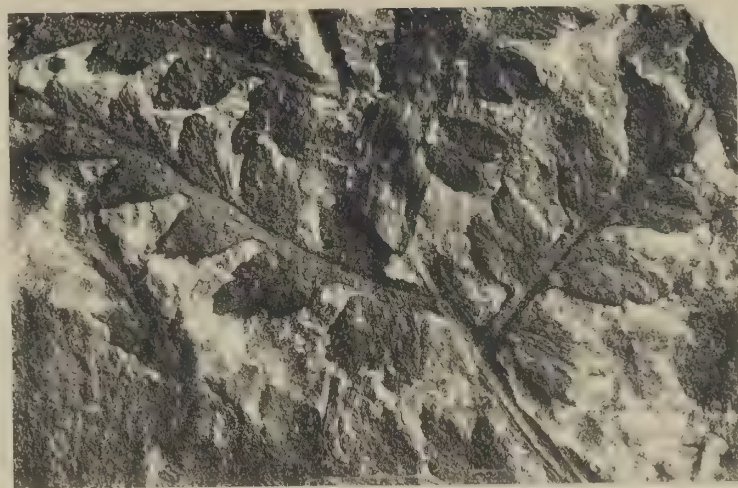
Fig. 2. *Mariopteris Daviesi* Kidston n. sp.
Parts of four ultimate pinnæ.
Same locality and horizon as last specimen.
Natural size. Collected by Mr D. Davies. Kidston Collection, No. 5738.

Fig. 3. *Mariopteris Daviesi* Kidston n. sp.
The upper end of the petiole, showing the dichotomy that divides the frond into two sections.
Locality.—Dinas Main Level, Gilfach Goch, Glamorganshire.
Horizon.—No. 2 Rhondda Seam. Blackband Group. Staffordian Series.
Natural size. Collected by Mr D. Davies. Kidston Collection, No. 5634.

Fig. 4. *Mariopteris sp.* (A).
Fragment of a frond.
Locality.—Mitchell's Main Colliery, Wombwell, 4½ miles south-east of Barnsley, Yorkshire.
Horizon.—Parkgate Coal. Westphalian Series.
Natural size. Collected by the Rev. R. H. Goode. Kidston Collection, No. 6031.

Fig. 4*a*. *Mariopteris sp.* (A).
Portion of last specimen, enlarged two times to show the form of the pinnules and the two prominent marginal ridges on the rachis.

1a



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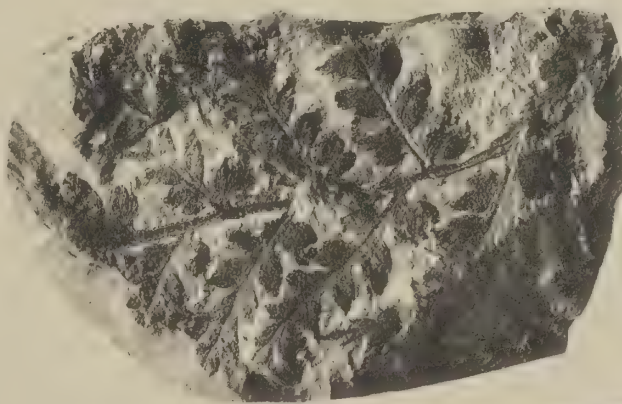

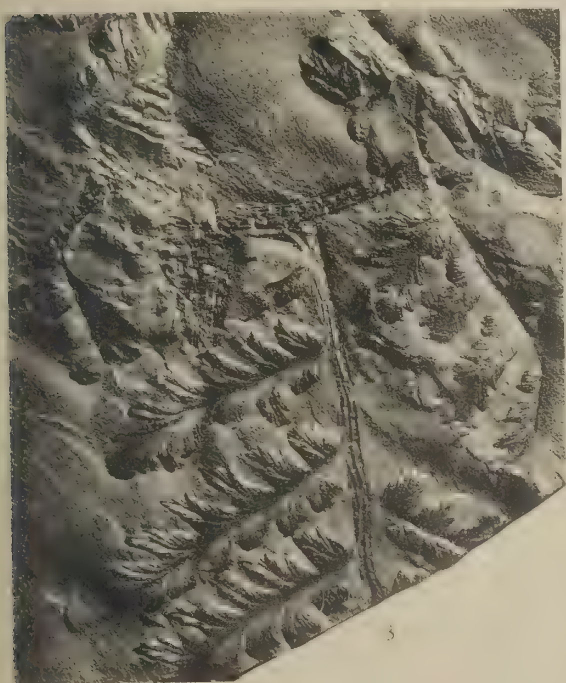

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PLATE CXLVII.

Fig. 1. *Mariopteris plumosa* Kidston n. sp.

Portion of a frond.

Locality.—Camerton, 2 miles north of Radstock, Somersetshire.

Horizon.—?. Radstock Group. Radstockian Series.

Natural size. Collection of British Museum, Geological Department, No. 52567.

Fig. 1*a*. *Mariopteris plumosa* Kidston n. sp.

Two penultimate pinnæ from the last specimen, enlarged two times to show the form of the confluent pinnules.

Fig. 1*b*. *Mariopteris plumosa* Kidston n. sp.

An ultimate pinna from the same specimen, enlarged two times to show the form of the pinnules and their nervation.

Fig. 2. *Mariopteris sp.* (B).

Part of a pinna.

Locality.—Elsecar Colliery, Wentworth, Yorkshire.

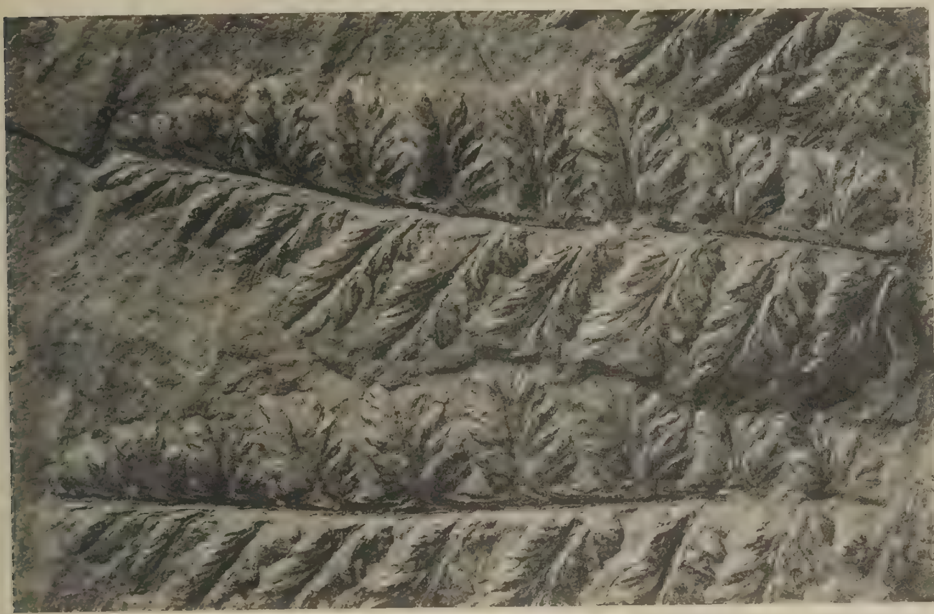
Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Kidston Collection, No. 6103.

MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

Palaeontology. Vol. II. 1925.

Plate CXLVII.



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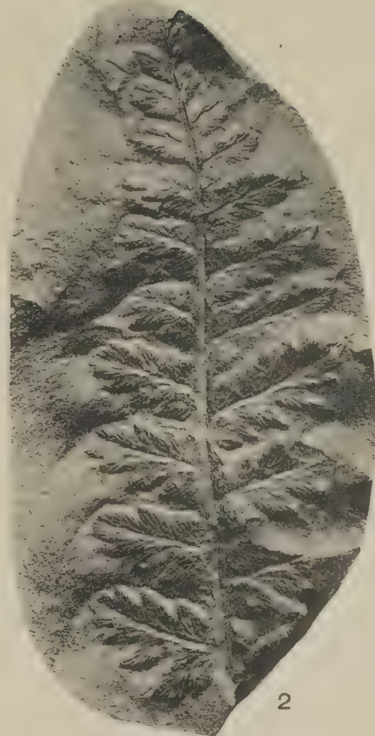

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PLATE CXLVIII.

Fig. 1. *Mariopteris Soubeirani* Zeiller.
Fragments of pinna.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1453.

Figs. 1*a*, 1*b*. *Mariopteris Soubeirani* Zeiller.
Tertiary pinnæ from same specimen, enlarged two times to show form of the pinnules and their nervation.

Fig. 2. *Mariopteris Soubeirani* Zeiller.
Penultimate pinnæ.
Same locality and horizon as previous specimen.
Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1945.

Fig. 2*a*. *Mariopteris Soubeirani* Zeiller.
Tertiary pinnæ from last specimen, enlarged two times to show their form.

Fig. 3. *Mariopteris sp.* (C).
Fragment of a penultimate pinna.
Locality.—Glynogwr Colliery, Gilfach Goch, Glamorganshire.
Horizon.—Three Coals Seam (A). Blackband Group. Staffordian Series.
Natural size. Collected by Mr D. Davies. Kidston Collection, No. 6080.

Fig. 3*a*. *Mariopteris sp.* (C).
Portion of last specimen, enlarged two times to show the form of the pinnules and their nervation.

MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

Palaeontology. Vol. II. 1925. Plate CXLVIII.

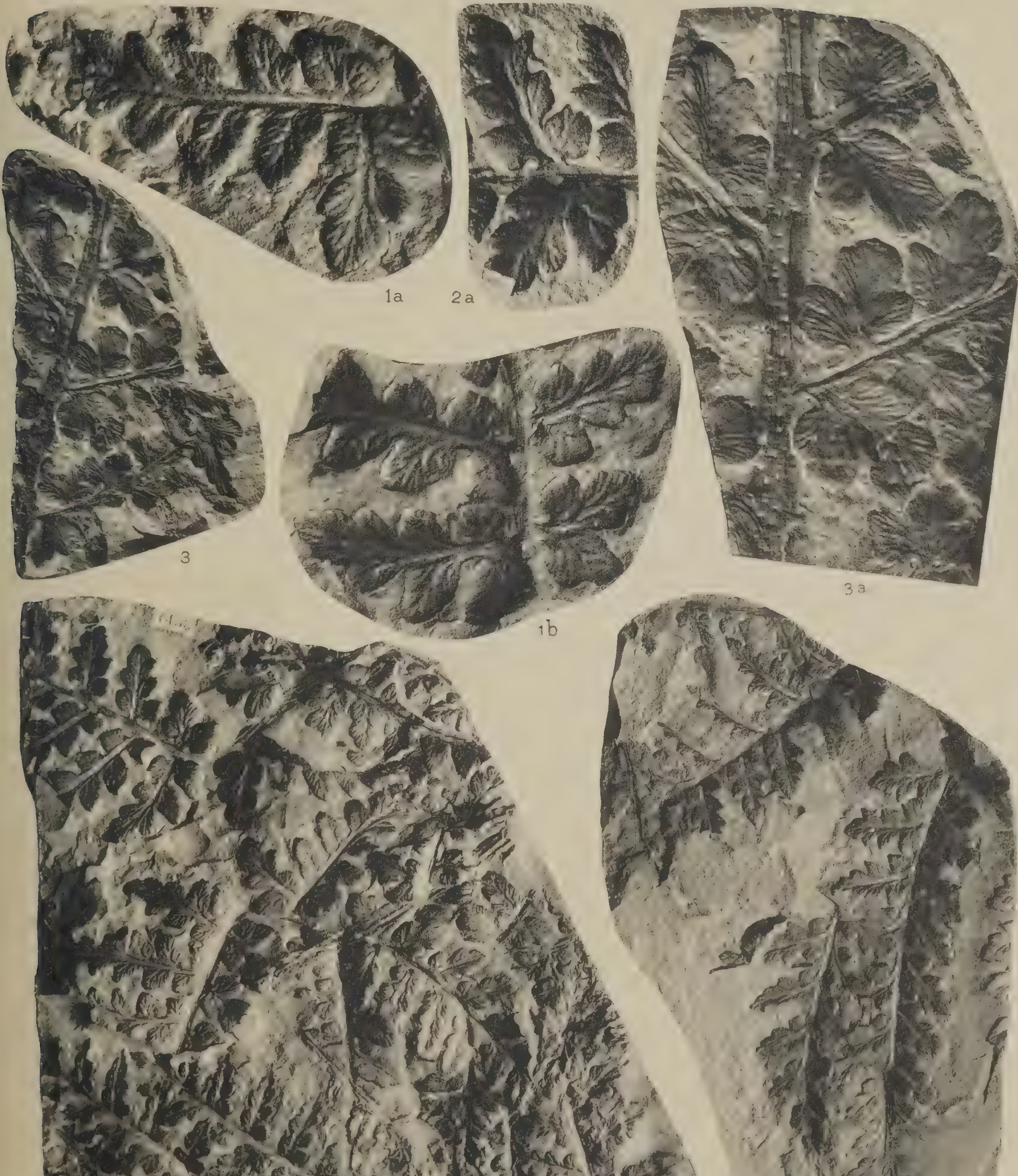

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PLATE CXLIX.

Fig. 1. *Mariopteris sp.* (D).
An ultimate pinna.
Locality.—Standard Collieries, Ynyshir, Glamorganshire.
Horizon.—No. 2 Rhondda Seam. Blackband Group. Staffordian Series.
Natural size. Collected by Mr R. WEED. Kidston Collection, No. 4058.

Fig. 2. *Mariopteris sp.* (D).
An ultimate pinna.
Same locality and horizon as last specimen.
Natural size. Collected by Mr R. WEED. Kidston Collection, No. 4057.

Fig. 3. *Mariopteris sp.* (D).
An ultimate pinna.
Same locality and horizon as previous specimen.
Natural size. Collected by Mr R. WEED. Kidston Collection, No. 4059.

Fig. 3*a*. *Mariopteris sp.* (D).
Part of last specimen, enlarged two times to show the nervation.

Fig. 4. *Mariopteris nobilis* Achepohl sp.
Part of a pinna.
Locality.—Glamorgan Colliery, Gilfach Goch, Glamorganshire.
Horizon.—No. 3 Rhondda Seam. Blackband Group. Staffordian Series.
Natural size. Collected by Mr D. DAVIES. Kidston Collection, No. 5661.

Fig. 4*a*. *Mariopteris nobilis* Achepohl sp.
The last specimen, enlarged two times to show the form of the pinnules and their nervation.

Fig. 5. *Mariopteris nobilis* Achepohl sp.
Fragment of a pinna, enlarged two times to show the form of the pinnules and their nervation.
Same locality and horizon as previous specimen.
Collected by Mr D. DAVIES. Kidston Collection, No. 5660.

Fig. 6. *Mariopteris obovata* Kidston n. sp.
Fragment of a bipinnate pinna.
Locality.—Dowles Brook, near Bewdley, Worcestershire.
Horizon.—?. Westphalian Series.
Natural size. Kidston Collection, No. 6084.

Fig. 6*a*. *Mariopteris obovata* Kidston n. sp.
Part of last specimen, enlarged two times to show form of pinnules and their nervation.

Fig. 7. *Mariopteris obovata* Kidston n. sp.
Part of a bipinnate pinna.
Same locality and horizon as previous specimen.
Natural size. Kidston Collection, No. 6085.

Fig. 7*a*. *Mariopteris obovata* Kidston n. sp.
Part of an ultimate pinna from last specimen, enlarged two times to show form of pinnules and their nervation.

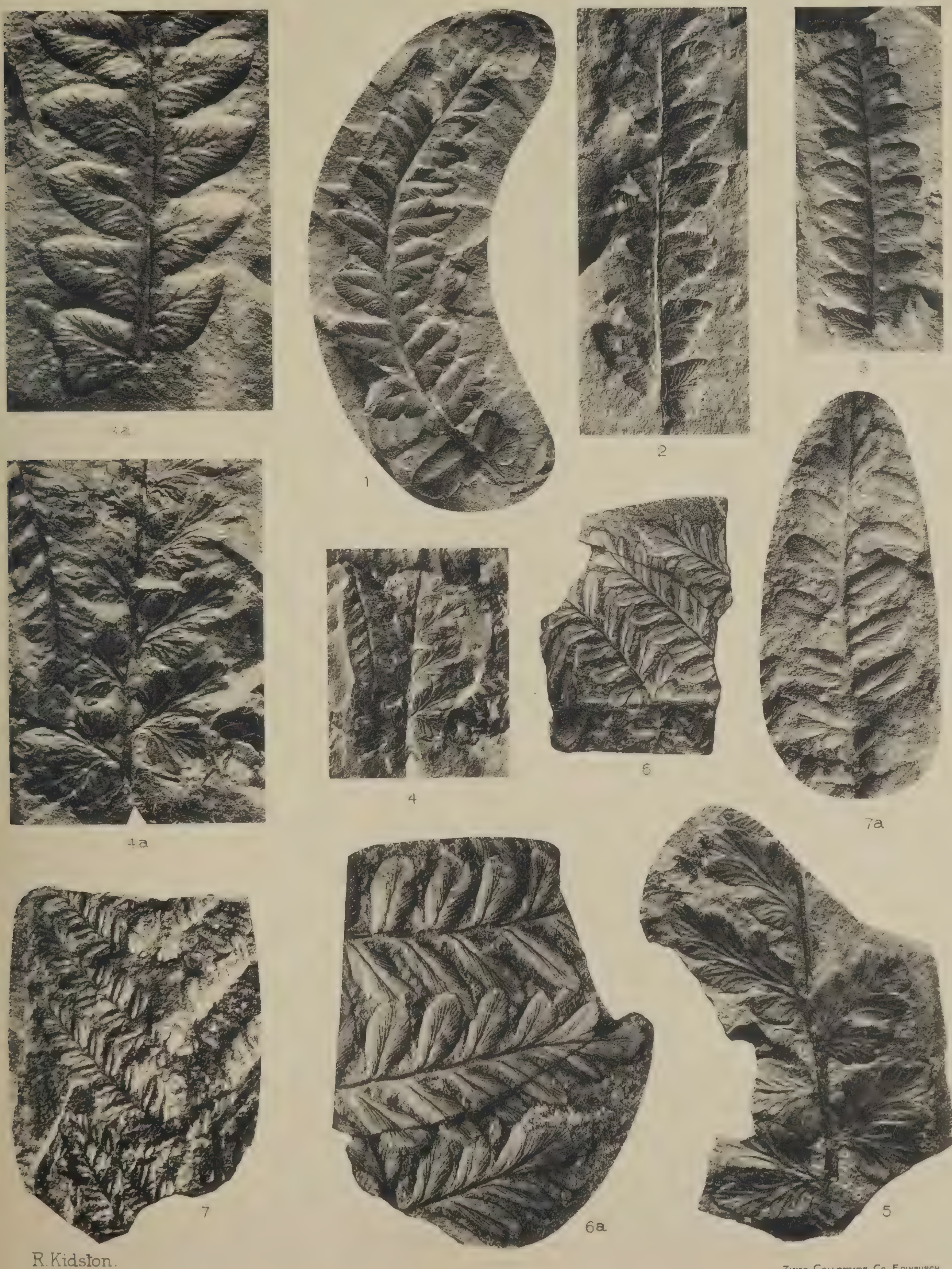

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PLATE CL.

Fig. 1. *Mariopteris Jacquoti* Zeiller sp.

Fragment of a frond.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1665.

Fig. 2. *Mariopteris acuta* Brongniart sp.

Fragment of a frond.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 2393.

Fig. 2*a*. *Mariopteris acuta* Brongniart sp.

Pinnules from last specimen, enlarged three and a half times to show the nervation.

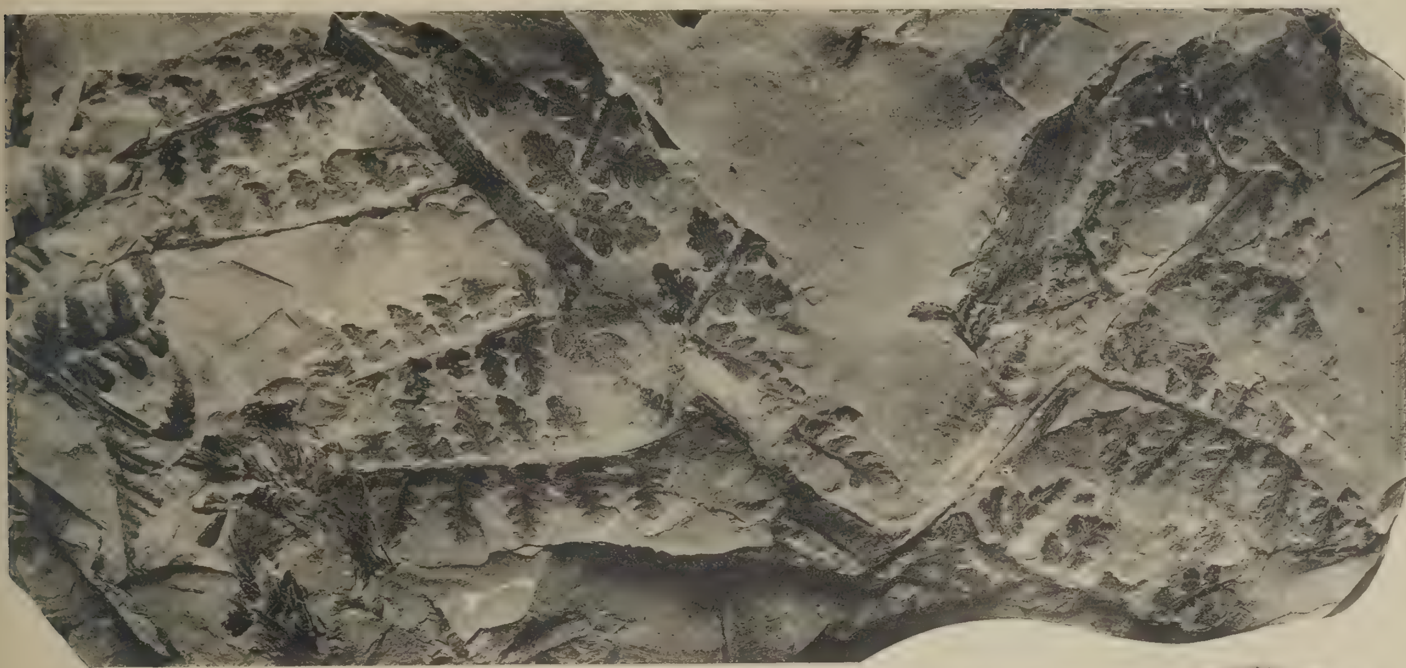

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PLATE CLI.

Fig. 1. *Mariopteris sp.* (E).

Portion of a bipinnate pinna.

Locality.—Bentley Shaft Sinking, $2\frac{1}{2}$ miles north of Doncaster, Yorkshire.

Horizon.—318 feet above Barnsley Coal. Westphalian Series.

Natural size. Collected by Mr H. Culpin. Kidston Collection, No. 4004.

Fig. 2. *Mariopteris Jacquoti* Zeiller sp.

Fragments of ultimate pinnæ.

Locality.—Kinlet Colliery, east of Tip House, 1 mile south-west of Highley, Shropshire.

Horizon.—Brooch Coal. Westphalian Series.

Natural size. Collected by Mr T. H. Stonehouse. Kidston Collection, No. 5861.

Fig. 2*a*. *Mariopteris Jacquoti* Zeiller sp.

Part of an ultimate pinna seen on last specimen, enlarged two times to show form of pinnules and their nervation.

Fig. 3. *Mariopteris Jacquoti* Zeiller sp.

Ultimate pinnæ from specimen shown on Pl. CL, fig. 1, enlarged two times to show the form of the pinnules.

Fig. 4. *Mariopteris acuta* Brongniart sp.

Fragment of ultimate pinnæ.

Locality.—Blairpoint, Dysart, Fife.

Horizon.—Near the base of the Coal-bearing strata. Lanarkian Series.

Natural size. Kidston Collection, No. 4030.

Fig. 4*a*. *Mariopteris acuta* Brongniart sp.

Pinnules from last specimen, enlarged two times to show the form and serration of their margins.

Fig. 5. *Mariopteris acuta* Brongniart sp.

Fragment of bipinnate pinnæ.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 1243.

Fig. 5*a*. *Mariopteris acuta* Brongniart sp.

Ultimate pinna from last specimen, enlarged two times to show the form and serration of the pinnules.

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PLATE CLII.

Fig. 1. *Mariopteris Dernoncourti* Zeiller.
Specimen showing a dichotomy of the petiole at its apex.
Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.
Horizon.—Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 1946.

Fig. 2. *Mariopteris Dernoncourti* Zeiller.
Fragment of a bipinnate pinna.
Locality.—Old Silkstone Colliery, Silkstone, Yorkshire.
Horizon.—Parkgate Coal. Westphalian Series.
Natural size. Collected by Mr W. HEMINGWAY. Kidston Collection, No. 6102.

Fig. 2*a*. *Mariopteris Dernoncourti* Zeiller.
Pinnules of last specimen, enlarged two times to show the nervation.

Fig. 3. *Mariopteris Dernoncourti* Zeiller.
Fragments of pinnæ.
Locality.—Pildacre Colliery, Ossett, Yorkshire.
Horizon.—?. Westphalian Series.
Natural size. Collected by Mr STANLEY NETTLETON. Kidston Collection, No. 3717.

Fig. 3*a*. *Mariopteris Dernoncourti* Zeiller.
Ultimate pinnæ from last specimen, enlarged two times to show the form of pinnules and their nervation.

Fig. 4. *Mariopteris Beneckei* Huth.
Fragments of pinnæ.
Locality.—Low Moor, Yorkshire.
Horizon.—White Rake Bed. Westphalian Series.
Natural size. Kidston Collection, No. 1406.

Fig. 4*a*. *Mariopteris Beneckei* Huth.
Ultimate pinna from last specimen, enlarged two times to show the form of the pinnules.

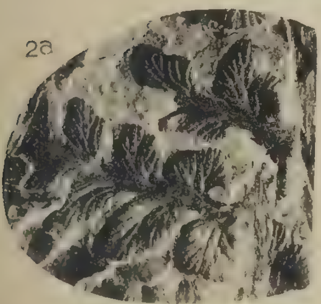
Fig. 5. *Mariopteris Beneckei* Huth.
An ultimate pinna.
Locality.—Brodsworth Sinking, 4 miles north-west of Doncaster, Yorkshire.
Horizon.—46½ feet above Barnsley Coal. Westphalian Series.
Natural size. Collected by Mr H. CULPIN. Kidston Collection, No. 3891.

Fig. 5*a*. *Mariopteris Beneckei* Huth.
Part of last specimen, enlarged two times to show the fine serration on the margin of some of the lobes of the pinnules.

1

4

2a



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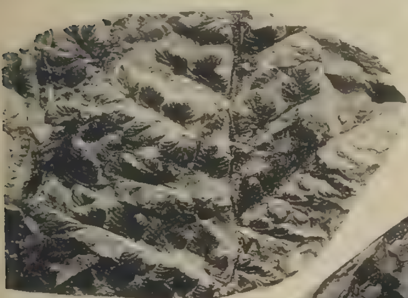

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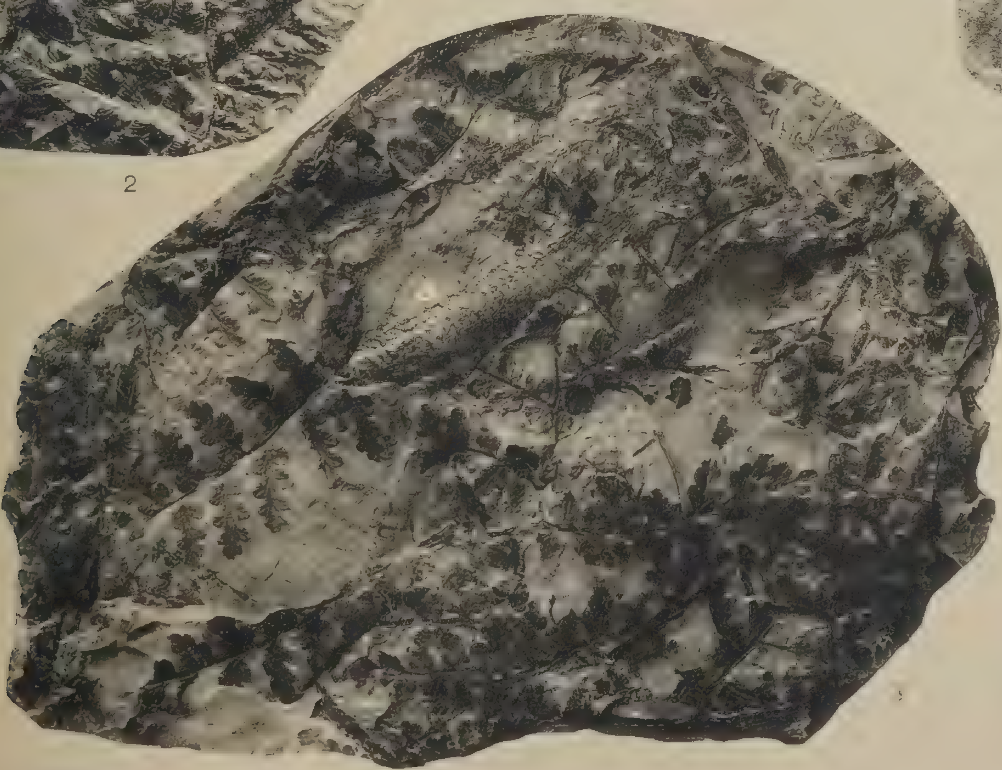

3

4a

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PLATE CLIII.

Fig. 1. *Mariopteris nervosa* Brongniart sp.

Photograph by reflected light of a transfer preparation. The shale (white in the photograph) has not been etched away completely in order that the glandular hairs, *h*, may be shown projecting through it. Enlarged two times.

Fig. 2. *Mariopteris nervosa* Brongniart sp.

The upper cuticle, showing the outline of the epidermal cells. Glandular hair bases are seen at *h*, *h*.

Enlarged sixty times.

Fig. 3. *Mariopteris nervosa* Brongniart sp.

The under cuticle, showing the outlines of the epidermal cells. Small folds in the cuticle marking the courses of the veins, *v*. Groups of papillæ on the epidermal cells surrounding each stoma, *p*.

Enlarged sixty times.

Fig. 4. *Mariopteris nervosa* Brongniart sp.

Upper cuticle with adherent microspores.

Enlarged two hundred and thirty times.

Fig. 5. *Mariopteris nervosa* Brongniart sp.

One of the stomata on the under surface. The papillæ, in this example, five in number, surround the stomal depression in the epidermis. The guard cells of the stoma itself are at a slightly lower level and can be seen within the ring formed by the papillæ.

Enlarged four hundred and forty times.

Fig. 6. *Mariopteris nervosa* Brongniart sp.

A glandular hair, situated at the edge of a fold in the cuticle, seen in profile. Some microspores are sticking to the cuticle near the hair.

Enlarged eighty-three times.

Fig. 7. *Mariopteris nervosa* Brongniart sp.

Portions of two primary pinnæ. That at *a* shows one of the two arms of the dichotomy attached to the summit of the naked rachis. That at *b* lies on a lower level in the stone, but is probably part of the other arm of the dichotomy.

Locality.—Bent Colliery, 1½ miles east of Bothwell, Lanarkshire.

Horizon.—Kiltongue Coal. Sixty fathoms below the surface. Lanarkian Series.

Natural size. Collected by Mr R. Dunlop. Kidston Collection, No. 96.

Fig. 8. *Mariopteris nobilis* Achepohl sp.

Under surface of pinnæ, showing adpressed hairs.

From specimen given on Pl. CXLIX, fig. 4. Enlarged sixteen times.

Fig. 9. *Mariopteris* stem.

Stem, showing a bunch of roots springing from the side.

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire.

Horizon.—Barnsley Coal. Westphalian Series.

Natural size. Collected by Mr W. Hemingway. Kidston Collection, No. 5002.

(Figs. 2–6 on this plate are from photographs by Mr John Walton, of the University of Manchester, reproduced by permission from the "Annals of Botany," vol. xxxvi, pl. ix, 1923.)

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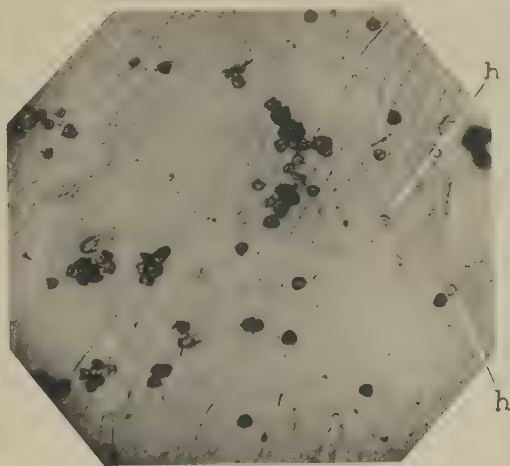

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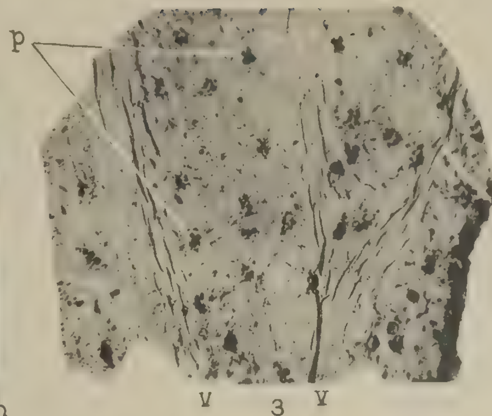

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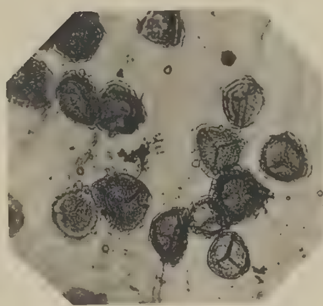

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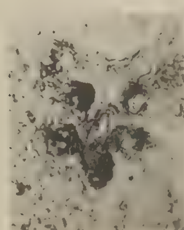

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